RI bureau of mines
report of investigations 6018

LEAD-SILVER DEPOSITS IN THE OMILAK AREA, SEWARD PENINSULA, ALASKA

By John J. Mulligan

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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by

John J. Mulligan[2]

INTRODUCTION AND SUMMARY

Lead-silver deposits in the Omilak area, on the western slopes of the Darby Mountains, Seward Peninsula, Alaska, were investigated by the Bureau of Mines, during the 1953 and 1954 field seasons, as a part of the U.S. Department of Interior's continuing program for the development of Alaska's resources. The Omilak area was the scene of early day prospecting and mining activity. The Omilak mine, which operated from 1881 to 1890, was the second producing lode mine in Alaska; the first was a small gold mine near Sitka. Several hundred tons of ore were produced at the Omilak mine; as an indication of grade, 41 tons shipped from Omilak in 1889 contained 75 percent lead and 142 ounces of silver per ton.

A prominent, nearby occurrence of lead-silver minerals, found but not explored during this period, has since become known as the Foster prospect. Subsequent exploration of this prospect revealed an abundance of massive galena occurring on an outcrop and as float scattered through limestone talus. Evidence of lead deposition, together with the generally high silver content of lead ores previously shipped from the district, indicated that deposits might be found which would be commercially valuable even in this remote area. To investigate the possibility, the Bureau of Mines made a reconnaissance of the Omilak area and did bulldozer trenching, diamond core drilling, and sampling at the Foster prospect. Data resulting from the investigation are presented in detail in this report and are summarized in the following paragraphs.

The western slopes of the Darby Mountains are composed of a series of extensively folded Paleozoic or possibly pre-Paleozoic metalimestones and schists that are in contact, to the east, with a large granitic complex. The dominant geological structure of the Omilak area is a northward pitching anticline. The axis of this anticline is about 6 miles west of the granite-limestone contact. The lead deposits in the area occur as irregular replacements of limestone. At the Foster prospect the deposits are on the anticlinal

[1]Work on manuscript completed October 1961.
[2]Mine examination and exploration engineer, Bureau of Mines, Region I, Juneau, Alaska.

crest. The Omilak mine is about 3 miles from the Foster prospect in a zone of local deformation imposed on the western limb of the anticline.

The Omilak mine workings are in a group of metalimestones with an outcrop width of about 700 feet and underlain and overlain by massive schists. The local deformation resulted in a maze of minor fractures and folds in the metalimestones, but there were not major faults. The mine workings were inaccessible, but a small stope, caved to the surface, appeared to have been 20 or 30 feet long, and possible 3 to 4 feet wide and oriented in a northwesterly direction. Typical specimens of high-grade galena picked up on the shaft dump contained from 55 to 71 percent lead and from 35 to 88 ounces of silver per ton.

The Foster prospect comprises a zonally arranged lead-silver-bearing gossan deposit extending about 700 feet along a line of fracturing having a general strike of N. 20° to 40° W. and an approximately vertical dip. To sample this deposit, the Foster pit was deepened, 7 trenches were excavated to delimit the outcrops, and 11 diamond-drill holes were drilled to depths ranging from 201 to 430 feet. Intensive fracturing, weathering, and leaching, extending to the greatest depths attained, made it impossible to determine definitely either the grade of the gossan or the nature of the primary deposits. Core and sludge recovery were notably poor and erratic.

The Foster pit exposes a gossan outcrop--about 90 feet long and 12 feet wide--composed principally of limonite and goethite with some cerussite and less anglesite; the only recognizable primary minerals are nodules of galena as much as 2 feet in diameter. Near the surface the outcrop resembled massive galena. This apparently was due to residual concentration because continued excavation indicated that galena nodules are less abundant at depth. Only minor to trace amounts of galena were found in the diamond-drill holes. The principal minerals found at depth were limonite, goethite, clay, quartz, and cerussite in irregular earthy deposits, interspersed with zones of hard, partially replaced silicified metalimestone.

Silver and lesser amounts of tin, zinc, copper, antimony, gold, and an unidentified radioactive mineral occur with the lead at the Foster prospect. The silver usually ranges from 0.2 to 0.4 ounce per ton, per percent of lead. Tin occurs, distributed through the gossan, in amounts ranging from a trace to 0.3 percent. This discovery extends the areas of known tin deposition and suggests that tin deposits may be found associated with the large granitic intrusives forming the core of the Darby Mountains. The other metals usually are present only in trace amounts.

The intensity and depth of weathering indicated by the diamond core drilling at the Foster prospect suggests that conditions in the area, and possibly throughout the Seward Peninsula, may be favorable for the formation of supergene deposits at or near the water table.

ACKNOWLEDGMENTS

The base maps were adapted from maps distributed by the Geological Survey. Information on the general geology and history of the area contained in Geological Survey publications was used in the preparation of this report (see bibliography).

The cooperation and material assistance given the field party of the Bureau of Mines by personnel of the Civil Aeronautics Administration (now Federal Aviation Agency) stationed at Moses Point and Golovin was especially valuable in this remote region and is gratefully acknowledged.

LOCATION AND ACCESSIBILITY

The Omilak area (figs. 1, 2, and 3) is in the Bendeleben Quadrangle, Seward Peninsula, Alaska, on the western slopes of the Darby Mountains, 90 miles east-northeast of Nome, and 36 miles north-northeast of Golovin, at latitude 65°02' N. and longitude 162°35' W. The area includes the valleys of Dry Creek, a headwater tributary of Omilak Creek, and the South Fork of Mosquito Creek. Both Omilak Creek and Mosquito Creek are tributaries of the Fish River. The Omilak mine is on the South Fork of Mosquito Creek; the Foster prospect, on which most of the Bureau of Mines work was done, is at the head of Dry Creek.

The area is uninhabited and is seldom visited; there are no roads or marked trails. A gravel road from Nome, open in summer only, ends at Council, about 35 miles to the west. The usual means of access is by bush planes that can be chartered at Nome, the transportation and supply center for the Seward Peninsula. The Bureau of Mines improved a natural airfield in Dry Creek Valley about 5 miles from the Foster prospect and about one-half mile west of the foothills of the Darby Mountains. The runway is 1,100 feet long and has been used by planes carrying a load of 1 ton.

Freight too heavy or bulky for bush planes usually is hauled overland by tracked-type tractors from the nearest point accessible to ocean shipping. The ocean shipping season extends from late June to late October. Bureau of Mines drilling equipment was landed at Golovin and hauled to the Omilak area on tractor-drawn sleds during the latter part of August. A circuitous route through the low hills south of the Fish River valley was followed to avoid marshy flats and deep streams. One way, the distance traveled was about 50 miles and the driving time varied from 45 to 60 hours. The 75 drawbar-horsepower tractor could pull about 1 or 2 tons on thawed ground, 3 to 5 tons on frozen ground and 10 tons or more on frozen snow-covered ground. Normally a trip can be made on frozen ground in about half the time it takes on thawed ground.

HISTORY AND PRODUCTION OF THE OMILAK AREA

Deposits of silver-bearing galena in the Darby Mountains have been known since the earliest trading posts were established on the Seward Peninsula; the traders apparently learned about them from Eskimos. Official mention of

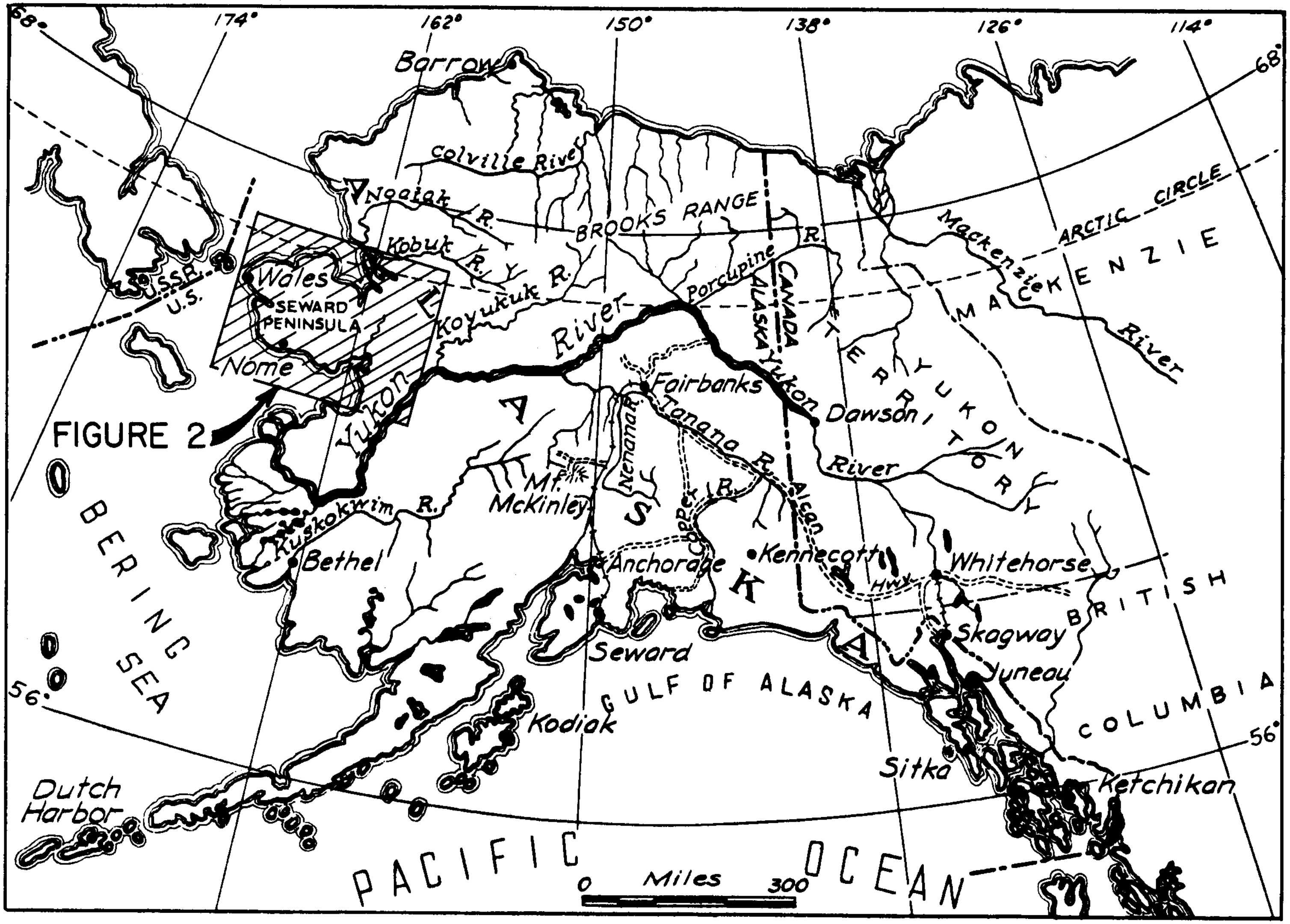

FIGURE 1. - Index Map of Alaska.

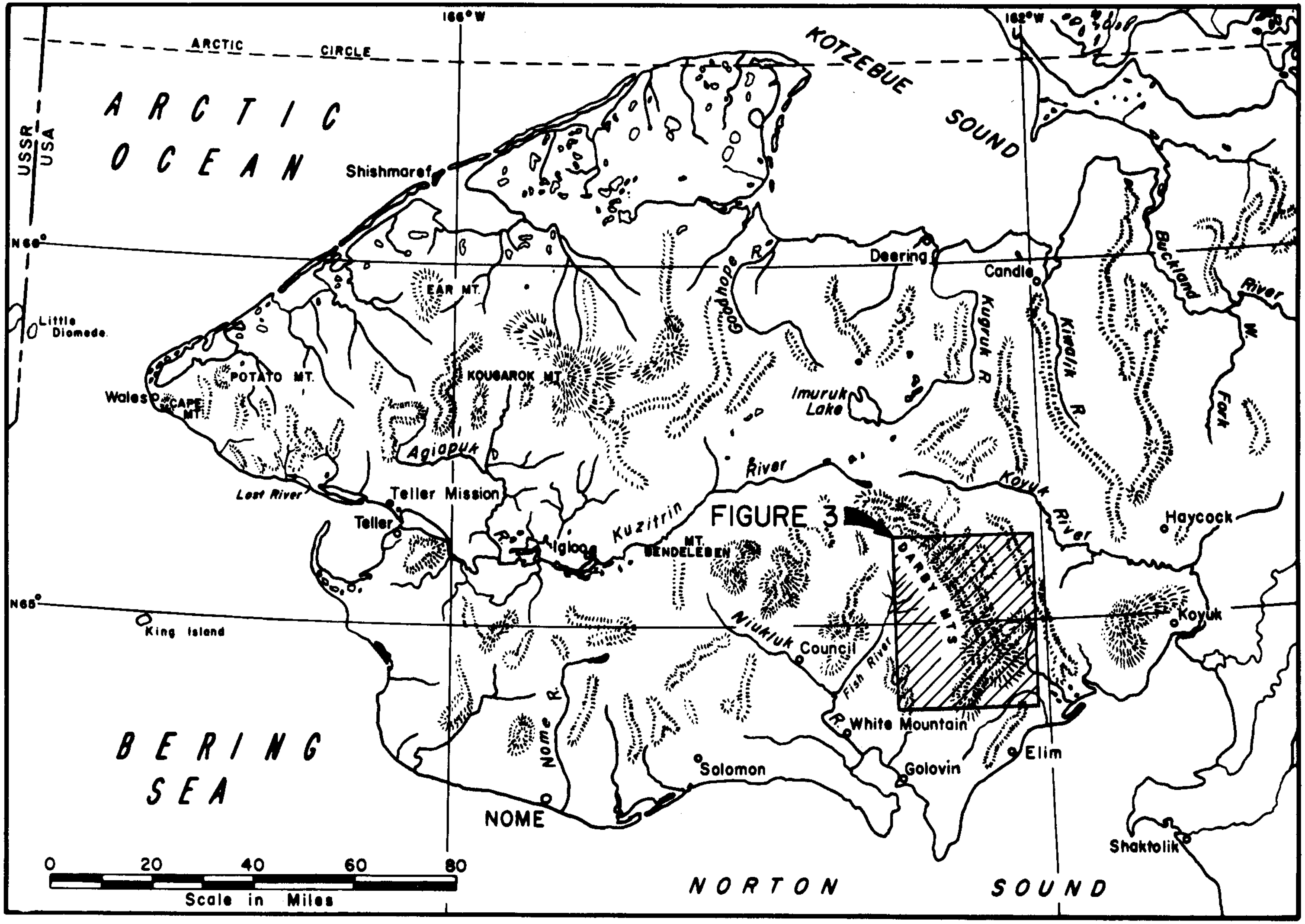

FIGURE 2. - Seward Peninsula.

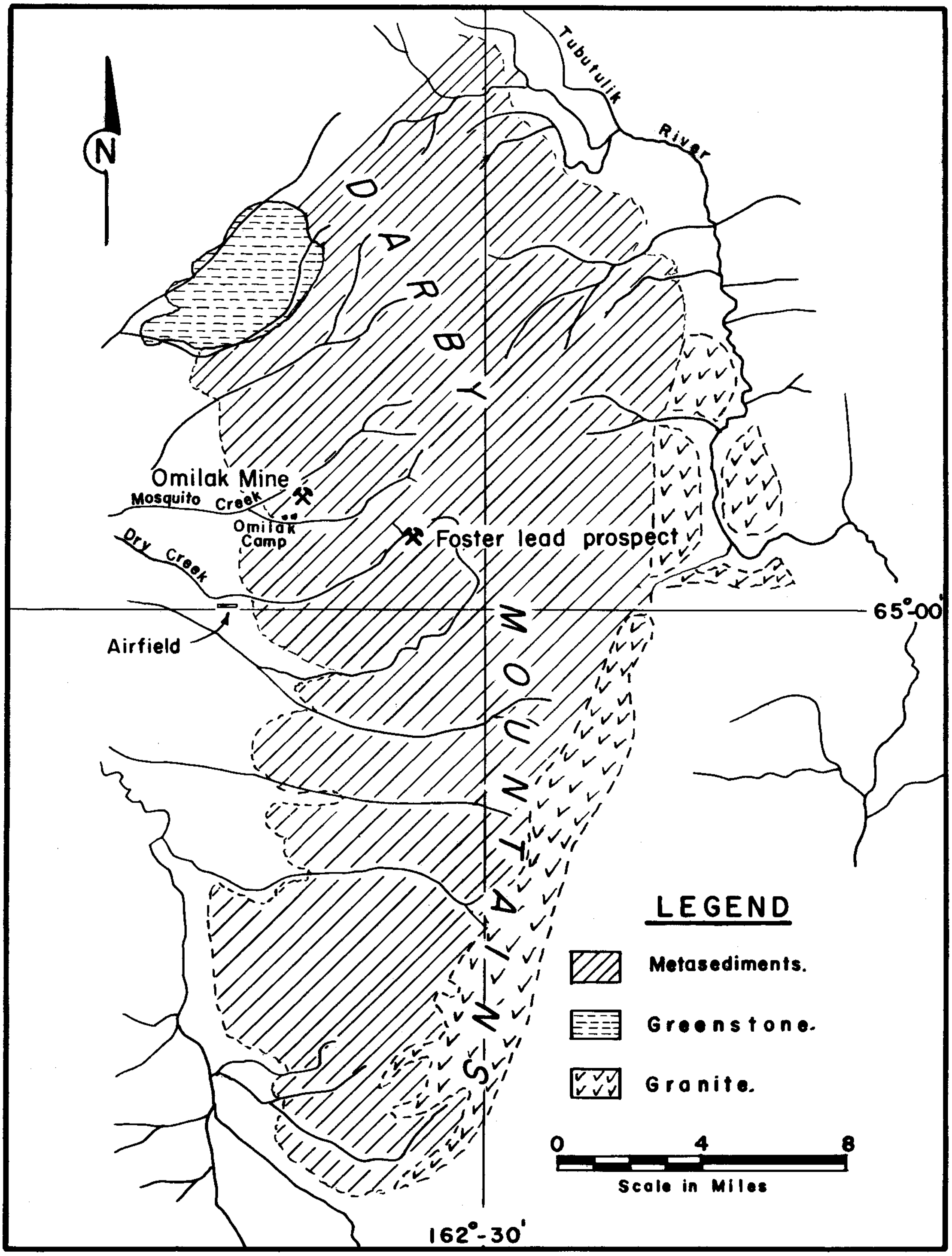

FIGURE 3. - General Geology, Darby Mountain Area.

lead deposits near Golovin Bay was made in the 1880 census by Petrof (4). In 1881, the Fish River mining district was organized and a company, headed by John C. Green of San Francisco, staked claims on an outcrop which was named the Omilak Mine. Omilak--also spelled Umilak, Umalik, and OOmilak--reportedly is a contraction of an Eskimo word meaning heavy rock. The Omilak mine became the second producing lode mine in Alaska; the first was a small gold mine near Sitka.

The Omilak mine (fig. 3) was on a low ridge extending from the western slopes of the Darby Mountains between the North Fork and South Fork of Mosquito Creek. The principal underground workings were a 180-foot vertical shaft on the crest of the ridge with two working levels and an adit on the south slope of the ridge driven about 500 feet to intersect the deposits at depth (4). Production was derived from the shaft operations and from surface float; no ore was found in the adit. In 1889, a shipment of 41 tons of picked ore contained 75 percent lead and 142 ounces of silver per ton; total production for the decade 1880 to 1890 has been estimated at between 300 and 400 tons. The ore was transported overland, about 6 miles, to a landing on Omilak Creek; it was then floated, in shallow-draft boats, about 75 miles down the Fish River to Golovin and transferred to ocean-going vessels.

Mining was suspended in 1890, but sporadic attempts to resume operations continued until the early 1920's. At the time of the Bureau's investigation, the shaft was full of ice and the entrance to the adit was caved. A variety of obsolete equipment and decaying buildings, reflecting several periods of operation, were found at the mine openings and at the main camp about one-half mile downstream on the South Fork of Mosquito Creek.

The Foster prospect also was discovered at an early date; several trenches and pits appeared to be contemporaneous with the workings at the Omilak mine, but no record of this early work could be found. In 1949, Neal W. Foster and Associates of Nome, Alaska, rediscovered the prospect and exposed the outcrop by bulldozer trenching. No production has been recorded, but several tons of hand-sorted ore were piled nearby.

The western part of the Darby Mountains has received very little scientific attention. In 1900, members of a Geological Survey party, which included W. C. Mendenhall, ascended the Fish River by canoe and visited the Omilak mine (1). In 1909, another Geological Survey party, headed by P. S. Smith and H. M. Eakin, traveled with packhorses and made a reconnaissance along the western face of the Darby Mountains (4). In 1952, a brief examination of the Foster prospect was made by Daniel A. Jones of the Department of Mines, Territory of Alaska. Topographic maps of the area were compiled from aerial photographs by the Geological Survey in cooperation with the Army Map Service and are available to the public from the Map Information Office, Geological Survey, Washington 25, D.C.

PHYSICAL FEATURES, CLIMATE, AND WATER SUPPLY

The Darby Mountains are a rugged range between two large interior basins, known as Death Valley or Tubutulik River Valley and the Fish River Flats. The mountains generally trend north-south and are characterized by deeply eroded valleys and steep slopes; summits range in altitude from 2,000 to more than 3,000 feet. The areas dominantly underlain by limestone are barren of vegetation and mantled with frostbroken rock fragments; the hill slopes approximate the angle of repose of this loose material and culminate in knifelike ridges. The areas dominantly underlain by schists are characterized by more rounded contours and support a sparse growth of tundra vegetation.

The Darby Mountains are near the western margin of tree growth. Small, widely scattered groves of spruce trees occur where the valleys open into the lowland basins. Mature trees have an average diameter of 6 to 8 inches and an average height of 30 to 40 feet. Willows and alders are common and in some places form dense thickets. The tundra vegetation of the lower hills and basins is reported to be good reindeer pasture.

The climate is typically subarctic and, except for the top few feet, the ground remains frozen throughout the year. Table 1 is a compilation of weather data obtained, principally, at White Mountain, about 35 miles southwest of the Omilak area.

TABLE 1. - Weather data, White Mountain, Alaska[1]

Average annual temperature...°F.	27.7
Average total annual precipitation...inches	14.83
Average total annual snowfall...do.	58.2
Average date of breakup: Fish River...	May 22
Average date of freezeup: Fish River...	Oct. 14
Average date of breakup: Golovin Bay...	May 20
Average date of freezeup: Golovin Bay...	Oct. 20
Average date of breakup: Norton Sound...	May 31[2]
Average date of freezeup: Norton Sound...	Nov. 11[2]
Highest recorded temperature...°F.	89
Lowest recorded temperature...°F.	-55
Prevailing wind direction...	North
Number of days per year when minimum temperature is 32° F. or lower...	[3]231

[1] Data furnished by the U.S. Weather Bureau.
[2] Date from observations made at Moses Point.
[3] Taken from Nome data; White Mountain may vary a few days.

Water for diamond drilling was obtained from the headwaters of Dry Creek. The water became available during the latter part of May when the snow started to melt, and from June to September, inclusive, the headwaters contained a fluctuating but usually ample supply. During the second week in October the stream dried up. Because the drainage basin is barren of vegetation, occasional flash floods washed out pumping installations. However, this did not seriously impede the work because the floods rarely lasted more than a few hours.

LABOR SUPPLY AND LIVING CONDITIONS

Unskilled, and some skilled labor, can be hired on the Seward Peninsula but skilled technicians and supervisory personnel usually must be recruited from other areas. A large percentage of the dominantly Eskimo and part-Eskimo population is available for employment because of the lack of industrial development. Table 2 lists the population of the southern part of the Seward Peninsula as recorded in the 1950 and 1960 census reports. Note that there was little change in population but half of the communities were abandoned.

Housing must be provided for employees at most places; tents or light, uninsulated frame cabins are adequate for summer use, but substantial, well-insulated buildings are needed for year-around operations. The only buildings in the Omilak area are the long-abandoned bunkhouses, shops and stables near the Omilak mine and a 12- by 14-foot uninsulated frame cabin at the Dry Creek airfield.

TABLE 2. - Population of the southern part of the Seward Peninsula

Places	Inhabitants		Places	Inhabitants	
	1950	1960		1950	1960
Council................	41	0	Nome..................	1,930	2,316
Elim..................	154	145	Solomon................	93	0
Golovin................	94	0	White Mountain.........	129	151
Haycock................	24	0	Total...............	2,599	2,741
Koyuk..................	134	129			

PROPERTY AND OWNERSHIP

The two groups of lode claims listed in table 3 were the only known mineral locations in the Omilak area. The patented claims cover the Omilak mine; the unpatented claims cover the Foster prospect. None of the claims were mapped during the investigation.

TABLE 3. - Lode claims

Omilak mine:

Pioneer Claim[1] .....19.91 acres
Omilak Claim[1] ......19.98 acres

Foster prospect:[2]

Claims:	Claims (Con.):	Claims (Con.):
Gossan No. 1	Would Be	Lode Claim No. 1
Gossan No. 2	Ridge	Lode Claim No. 2
Gossan No. 3	Utuan	Lode Claim No. 3
Gossan No. 4	Dry	Lode Claim No. 4
Bandy	Jim	Lode Claim No. 5
Benson	Darby	Lode Claim No. 6
Poppy	Darby No. 2	Lode Claim No. 7
		Lode Claim No. 8

[1] Patented on February 3, 1894, by the Omilak Gold and Silver Mining Co.
[2] Location notices for the above 22 unpatented claims are on file in the District Magistrate's Office, Second District, Nome, Alaska. Variations in the spelling of some names were noted.

GENERAL GEOLOGY

The geology of the Darby Mountains has not been studied in detail, but the general features are described in the Geological Survey publications listed in the bibliography. The following discussion of the general geology is based on data contained in these publications, but the local geology was mapped during the investigation and all interpretations based on geological evidence are those of the writer.

The western slopes of the Darby Mountains (fig. 3) consist of a series of Paleozoic--or possibly pre-Paleozoic--metasediments that rise abruptly from the thick alluvial cover of the Fish River basin. The metasedimentary exposure has a generally north-south orientation and an east-west width of from 2 to 10 miles; it is bordered on the east by a dominantly granitic igneous complex, probably of pre-Cretaceous age. The lower members of the sedimentary series are thin-bedded metalimestones, interspersed with a few thin beds of schist; the upper members are predominantly thick, alternating bands of metalimestones and quartzose schists. The Foster prospect is in the lower members of the metasedimentary series about 6 miles west of the granite-metalimestone contact. The Omilak mine is in the upper members of the series about 9 miles west of the contact.

The dominant geological feature of the Omilak area is a northward pitching anticline. The axis passes through the Foster prospect, and the Omilak mine is on the western limb. The anticlinal structure is well exposed on the southern slopes of the ridge, south-southeast of the Foster prospect (fig. 4). In this area the rocks are chiefly thin-bedded metalimestones with a few thin beds of schists. Many, if not most of these metalimestones, are dolomitic. Pronounced crenulations occur in some beds at the crest of the anticline; minor crenulations occur in most beds, but some beds are only gently folded. The differential folding resulted in a dense network of minor faults and joints, many of which contain calcite or clay filling. The individual faults and joints rarely extend through more than one bed or a series of thin beds; there is no evidence of major faults. Northward from the Foster prospect the anticlinal axis becomes more gently folded, crenulations are not apparent, and faulting and jointing are less pronounced.

Greenstones are the only recognizable igneous rocks that intrude the metasediments of the anticline. A prominent greenstone dike, about 1,500 feet north of the Foster prospect (fig. 4), generally strikes east-west, dips 70° to 80° S., and can be traced for about 1 mile. Locally it pinches and swells and, in some places, disappears; it is 15 to 20 feet wide at the east end and gradually pinches out to the west. Petrographic analyses showed that it contains altered feldspar with some serpentine, pyroxene, amphibole, and small amounts of magnetite, pyrite, chlorite, calcite, biotite, and limonite. Other greenstone intrusives are short discontinuous bodies, usually of uncertain orientation. A prominent outcrop of this type occurs in limestone about 2,000 feet south-southwest of the shaft at the Omilak mine. The more prominent greenstone intrusives are shown on figure 4, but the wide distribution of greenstone in the stream gravels indicates that many more are present. The greenstones have had no discernable influence on the distribution of lead minerals.

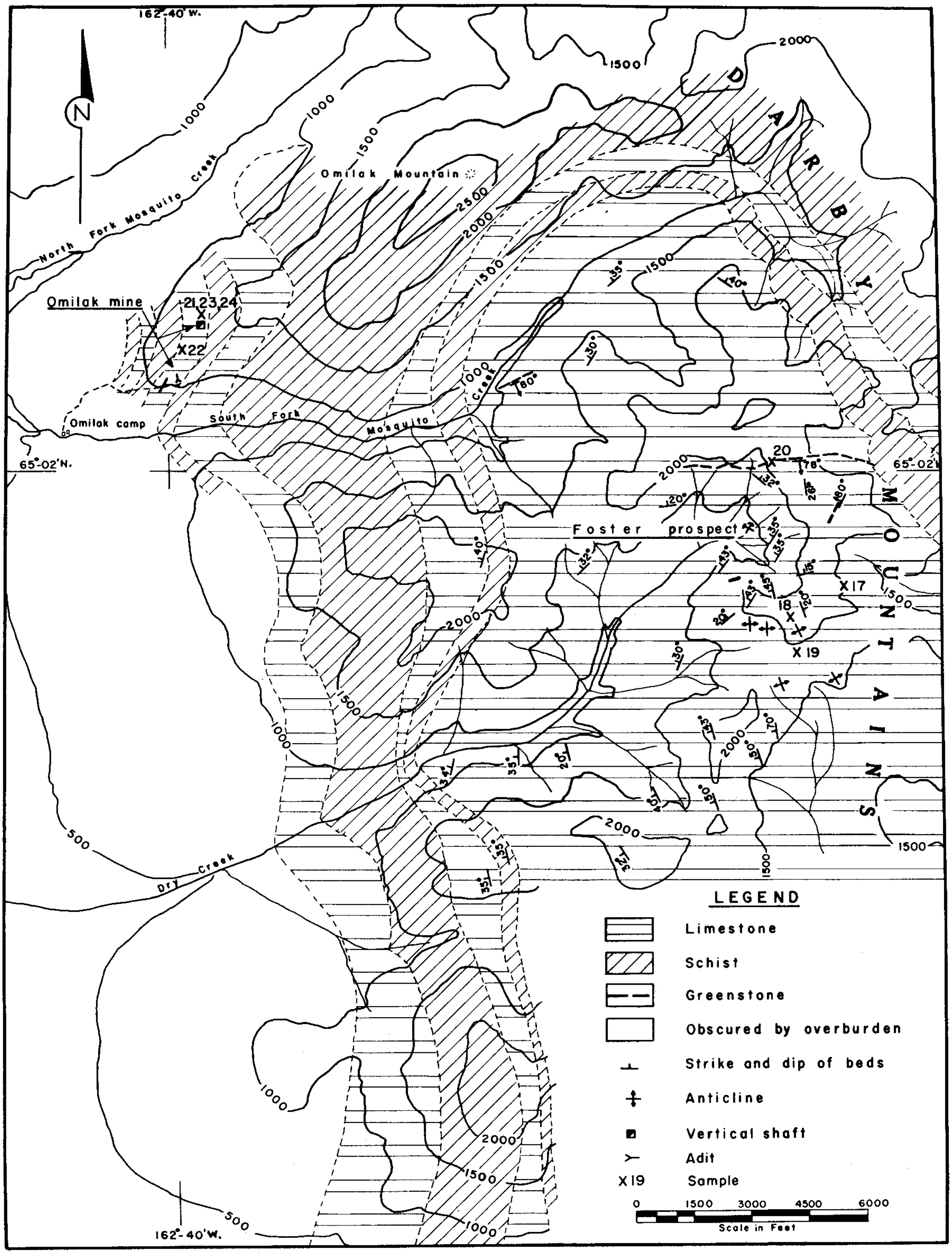

FIGURE 4. - Geology of the Omilak Area.

DESCRIPTION OF THE DEPOSITS

Foster Prospect

The Foster prospect comprises a zonally arranged lead-silver-bearing gossan deposit extending about 700 feet along a line of fracturing. The fracture system is on or near the axis of an anticline, generally strikes N. 20° to 40° W. and has a nearly vertical dip. The gossan material is principally limonite and goethite with some cerussite and less anglesite. The only recognizable primary mineral occurs as nodules of galena which are most abundant on the outcrop in the Foster pit but are also scattered in the overburden for a few hundred feet to the north and south.

The outcrop, exposed in the Foster pit (fig. 5), is about 12 feet wide and 90 feet long with poorly defined, irregular borders except where it is terminated abruptly to the northwest by hard, moderately bleached metalimestone. The southeast end is buried under a deep cover of overburden. Near the surface the outcrop resembles massive galena owing to residual concentration of galena nodules. The nodules range in size from less than an inch to about 2 feet in diameter and occur encased in oxidation products and imbedded in a matrix of ice, clay, and earthy oxides. The pit was excavated to a depth of about 20 feet without encountering much change except that the galena nodules were less abundant in the bottom than nearer the surface. The depth and degree of residual concentration are uncertain. No nodules large enough to core were encountered in the drill holes, but a few recognizable fragments of galena were recovered in the sludge samples.

The effects of intense weathering made it impossible to determine definitely the nature of the primary deposits. However, the position and type of remnant minerals would suggest that the primary deposits were derived from pneumatolytic solutions which invaded the metasediments after they had been folded into approximately their present positions. The solutions penetrated the more intensely fractured and broken zones and formed irregular deposits by replacing limestone. Most of the original constituents have been oxidized, and the soluble parts have been carried off, leaving only a relatively insoluble remnant.

Weathering and leaching effects similar in nature and intensity to those on the surface, extend to depths in excess of 400 feet--the practical depth-limit of the drilling equipment. Clay-filled solution channels and earthy oxide minerals in the fractures would indicate that the zone of downward percolating water extends below this depth; there is no indication of the depth to the water table. The intensity and depth of weathering suggests that, where confining structures exist, conditions on the Seward Peninsula may be favorable for the concentration of supergene deposits.

Omilak Mine

The Omilak mine (fig. 4) is in a zone of intense local deformation imposed on the western limb of the same anticline in which the Foster prospect occurs. The workings that can be seen are in a group of metalimestones,

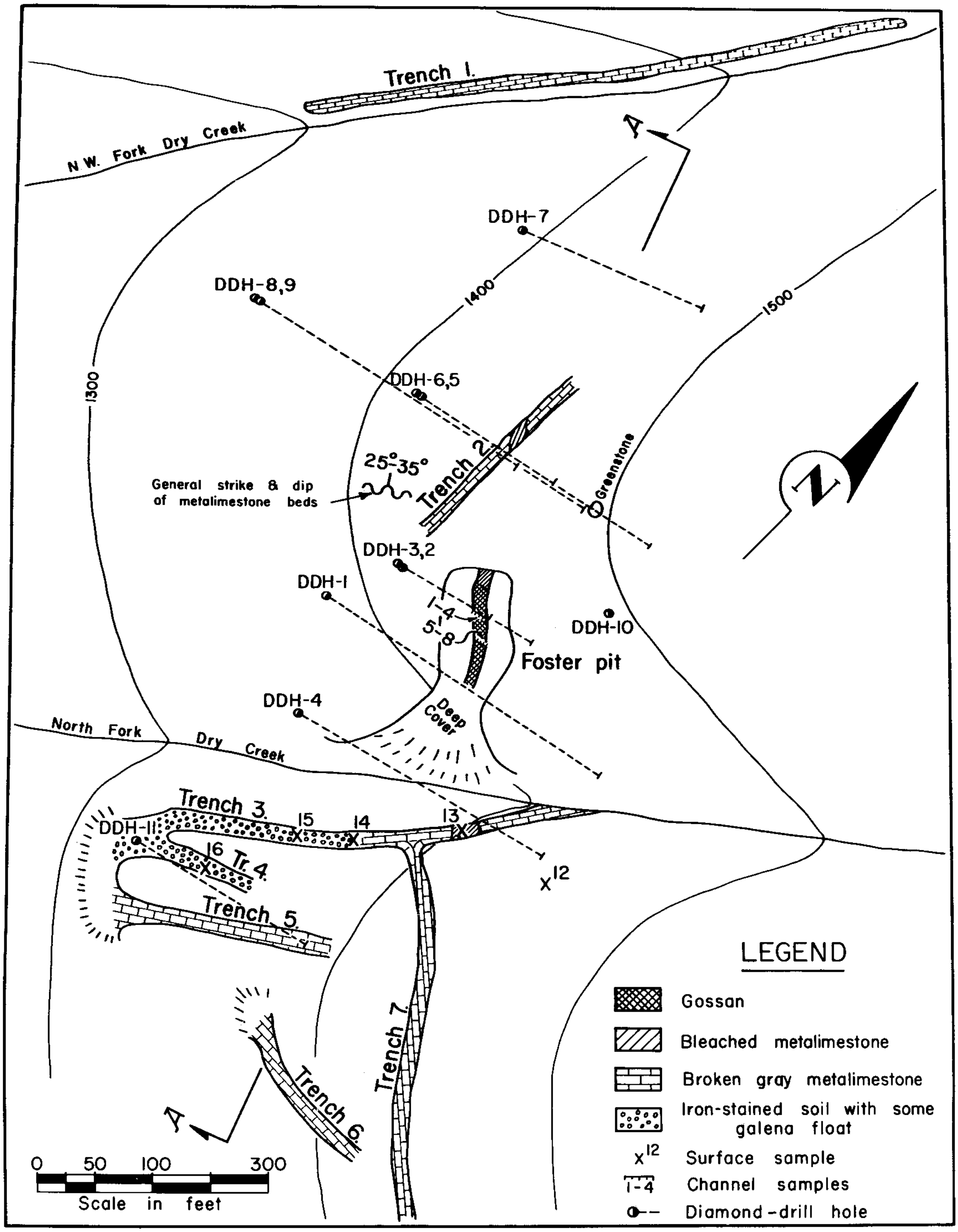

FIGURE 5. - Foster Prospect.

having an outcrop width of over 700 feet, which forms one band in a series of thick, alternating bands of metalimestones and schists. Stratigraphically, these rocks are over 5,000 feet and possibly as much as 10,000 feet above those at the Foster prospect.

The bedding near the Omilak mine generally strikes north-south and dips to the west, but both the schists and the metalimestones are intensely contorted. The schists are folded but have few joints or fractures. Many small folds, faults, and joints break the metalimestone beds although there is no evidence of major faults or breaks extending through a number of beds.

The Omilak deposit could not be seen in place because the outcrops had been removed during mining and the workings had either collapsed or were full of snow and ice. Near the shaft a small stope had caved to the surface. It appeared to have contained a lenticular ore body, possibly 20 to 30 feet long and 3 or 4 feet wide, entirely within the limestone and oriented in a northwesterly direction. Lead minerals found in the shaft dump and in small nearby fractures are similar in metal content to those at the Foster prospect, except that silver and stibnite appear to be more abundant at the Omilak mine. There is no evidence of a relationship between the deposits at the Omilak mine and the Foster prospect other than a general similarity of minerals and mode-of-occurrence.

BUREAU OF MINES WORK

The investigation started in the latter part of August 1953, when the heavier items of equipment and supplies were assembled at Golovin and hauled overland to the Omilak area. A natural airfield on Dry Creek was improved, and lighter items were flown from Nome or Golovin as needed. Previous bulldozer trenching at the Foster prospect had revealed that frostbreaking and intense weathering extended below the limits of surface excavation; therefore, diamond drilling was the most practical means of sampling the deposit. The drilling was supplemented by bulldozer trenching and by a reconnaissance of the area to determine the general geology and the relationship between the lead occurrences at the Foster prospect and the Omilak mine. Drilling started September 11, 1953, and stopped on October 11 of that year; work was resumed on June 1, 1954, and drilling was completed August 31, 1954. Reconnaissance of the area and surveying and mapping proceeded simultaneously with the drilling and trenching.

Bulldozer Trenching

Purpose and Extent

The original Foster pit was deepened to about 20 feet, and 7 additional bulldozer trenches were excavated to delineate the trend of the gossan outcroppings and to indicate the limits of deposition as a guide for diamond core drilling. The Foster pit, bulldozer trenches, and sample locations are shown in figure 5. Descriptions of samples and data of analyses are presented in tables 4 and 5.

TABLE 4. - Analyses of Foster pit samples[1]

Number[2]	Length, feet	Description	Percent			Ounces per ton	
			Pb	Zn	Fe	Au	Ag
1	3.0	Gossan....................	([3])	1.7	5.7	([4])	([4])
2	3.0	do......................	0.6	2.6	9.0	0	0.14
3	3.0	do......................	9.5	7.6	23.3	([3])	1.40
4	3.0	do......................	22.1	.2	37.8	([3])	5.68
5	3.0	do......................	6.8	([3])	39.8	([3])	2.75
6	3.0	do......................	2.2	.1	19.7	([4])	([4])
7	3.0	do......................	11.6	.1	42.5	([3])	4.74
8	3.0	do......................	25.6	.1	17.6	([3])	14.90
9	-	Typical galena nodules.....	48.0	.2	17.6	0	23.40
[5]10	-	High-grade galena..........	80.0	([3])	([4])	([3])	25.42
[6]11	-	Wall rock.................	([3])	([4])	([4])	([4])	([4])

[1] Sample locations are shown on figure 5.

[2] Numbers 1 through 8 are channel samples; numbers 9 through 11 are selected specimens.

[3] Trace.

[4] No assay.

[5] Sample 10, petrographic analyses: Galena, cerussite, and anglesite with some associated limonite and small amounts of hornblende, arsenopyrite, chalcopyrite, quartz, and pyrite. Spectrographic analyses follows:

Al	Sb	As	Sn	Cu	Pb	Ag	Zn	Fe	Ni	Si	Ti
D-	E	D	D	E	A	E	E	B-	E	E	F-

Legend:
- A - more than 10 percent.
- B - 5 to 10 percent.
- C - 1 to 5 percent.
- D - 0.1 to 1 percent.

Legend (Con.):
- E - 0.01 to 0.1 percent.
- F - 0.001 to 0.01 percent.
- G - less than 0.001 percent.

[6] Sample 11 petrographic analyses: Impure limestone containing magnesian-bearing calcite with a relatively small amount of limonite that occurs as stain.

Results

Generally, the approximate source of surface float could be found by trenching, but good bedrock samples could not be obtained because of the broken nature of the rock and the intensely weathered condition of the mineralized outcrops. The few samples obtained from trenches can be considered only as specimens. Trenches 1 and 2, encountered no gossan material although a few small galena fragments were found in overburden between the trenches. The only evidence of mineralizing solutions was some bleaching along fractures near the middle of trench 2. Iron-stained soil and occasional galena fragments, mixed with metalimestone debris, were encountered in the lower (southwest) half of trench 3 and in trench 4. This material apparently was derived from two or more small, poorly exposed fracture zones (samples 14 and 15). Sample 16 from trench 4 is a typical specimen of the high-grade float occasionally found in both trenches 3 and 4. The upper end of trench 3 exposed no gossan material but did expose slightly bleached metalimestone approximately in line with the outcrop in the Foster pit. Some small galena fragments, found on the bank above the upper end of trench 3 (sample 12), could not be traced to their source. Trench 7, therefore, was excavated to determine whether the amount of galena float in the forstbroken debris would indicate that extensions of the outcrop were exposed higher on the hillslope; only a few small fragments of lead-bearing float were found. Trenches 5 and 6 exposed only broken, gray metalimestone with some iron staining on fracture surfaces.

TABLE 5. - Analyses of trench samples[1]

Number	Description	Percent			Ounces per ton	
		Pb	Zn	Fe	Au	Ag
12	Small float specimens found above the N.E. end of trench 3.	69.6	(2)	5.7	0.01	30.36
13	Bleached metalimestone with iron-stained fractures, trench 3.	(2)	(3)	(3)	(3)	(3)
14	Gossan material in fracture zone about 1 foot wide, trench 3.	1.3	(3)	(3)	(3)	(3)
15	Gossan material from a small fracture, trench 3.	.05	(3)	(3)	(3)	(3)
[4]16	Specimen of high-grade float, trench 4.	51.4	(3)	(3)	.01	19.7

[1] Sample locations are shown on figure 5.
[2] Trace.
[3] No assay.
[4] Sample 16, petrographic analyses: Galena with some associated cerussite and small amounts of anglesite and limonite. Spectrographic analyses follows:

Al	Sb	As	Sn	Ca	Cu	Pb	Mg	Ag	Zn	Fe	Mn	Si	Ti	Mo	B
E+	E	C-	D	E	E	A	G	D	C	A	E	D	F	F	F

Legend:
A - more than 10 percent.
B - 5 to 10 percent.
C - 1 to 5 percent
D - 0.1 to 1 percent.

Legend (Con.):
E - 0.01 to 0.1 percent.
F - 0.001 to 0.01 percent.
G - less than 0.001 percent.

Diamond Core Drilling and Sampling

Methods and Conditions

The Foster prospect was explored by 11 holes totaling 3,015 linear feet drilled to depths of 201 to 430 feet. Conventional diamond-drilling equipment was used, and normal core-drilling procedures were followed. The core was logged by the project engineer. No sludge was saved from hole 1; sludge samples from the other holes were saved when the color of return water indicated the presence of metallic minerals. However, because of the porous nature of the rock, all or part of many sludge samples were lost.

The rock drilled was a much-broken series of metalimestones with a few thin beds of schist and sandstone. The mineralized zones and many of the other numerous openings contained an earthy claylike filling that could not be cored. Drilling was tedious and sample recovery was difficult, but the only problems not common to drilling similar rock in warmer climates resulted from the presence of permafrost.

Permafrost was encountered from a few feet below the surface to depths in excess of 350 feet. Hole 8 may have penetrated to unfrozen rock at a depth of 400 feet (measured down the hole), but the evidence was inconclusive and was based on the feel of the ground and the absence of ice in the samples. The openings in the permanently frozen rock were not completely ice filled; drilling water was lost frequently in all holes to the greatest depths attained. A strong inflow of ground water was encountered within the permafrost in hole 4 at a depth of 200 feet but was not encountered in other holes at greater depths.

The principal operating problem from permafrost was freezing of water in the drill holes when circulation stopped. No difficulty ensued while circulation was maintained. Measurements of the time required to form solid ice in a drill hole were not made; the time was believed to vary widely, probably dependant partly on the temperature of the circulating water and the length of time it had been circulated before the stoppage. Two hours after circulation stopped in hole 5, solid ice was encountered at 155 feet and had to be drilled to the bottom of the hole--at that time 265 feet. For practical purposes, it was found safe to assume that freezing never occurred in less than 45 minutes but might occur anytime thereafter. Antifreeze preparations were not used because of the frequent loss of drilling water.

Ice in the frozen rock had an initial tendency to support the walls of the drill holes, but, as drilling progressed, the ice would thaw and caving became serious. When casing was reamed down at frequent intervals, it showed less-than-normal tendency to bind; apparently casing limited the thawing effect by preventing circulating water from coming in direct contact with the frozen rock. The heat from the circulating water was ample to prevent the casing from freezing to the rock or to free it after it had frozen. On several occasions, when the drilling rods were not in the hole, the water in the casing froze with no apparent bad effects except that it was necessary to drill out the ice. Cementing the holes had only limited success; apparently freezing adversely affected the setting qualities of the cement.

Results

The drill hole locations are shown on figure 5. Vertical sections through the diamond-drill holes are shown in figures 6 through 12. The drill-hole logs, together with tabulated chemical, petrographic, and spectrographic analyses of core and sludge samples are presented in tables 6 through 26.

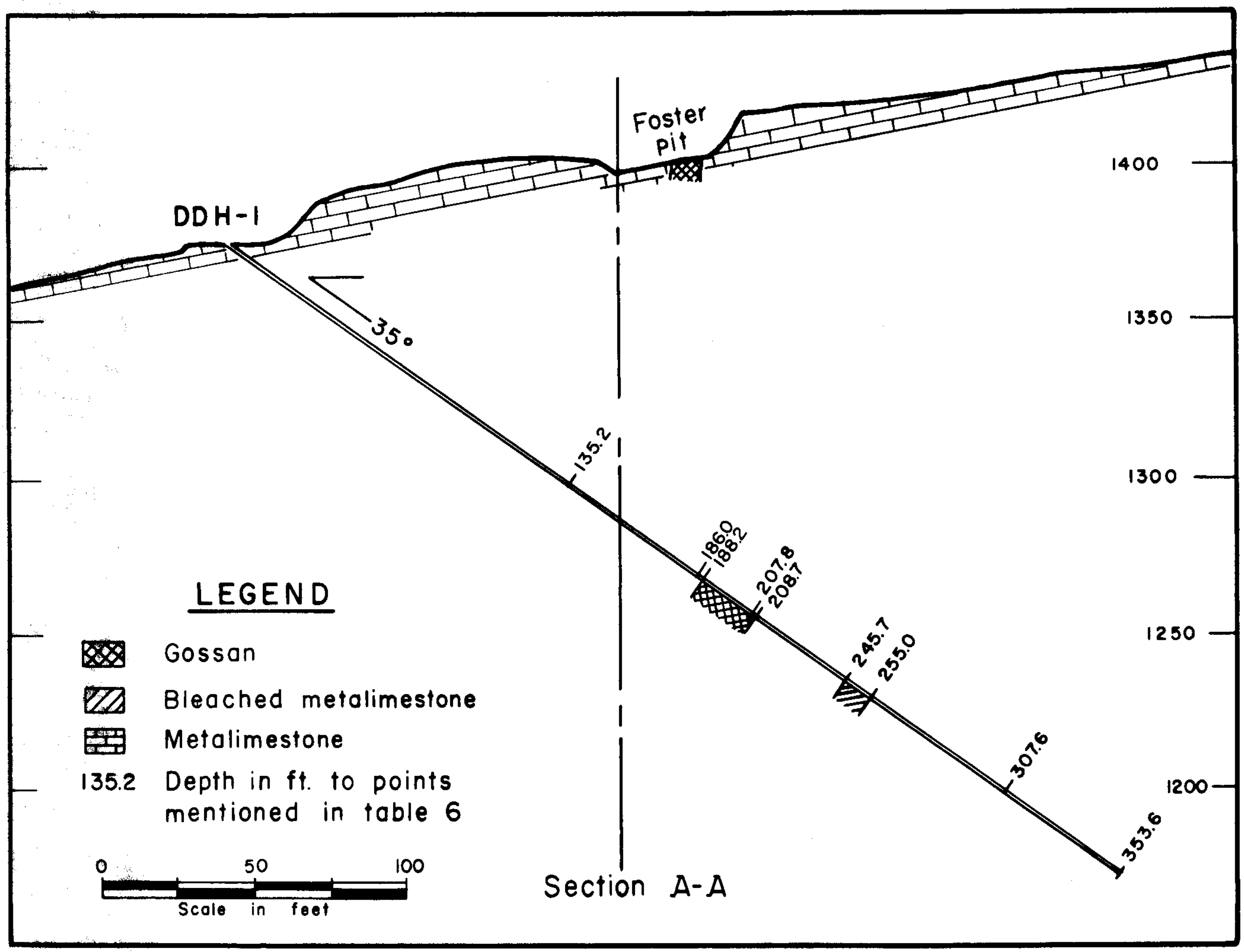

FIGURE 6. - Vertical Section Through Diamond-Drill Hole 1.

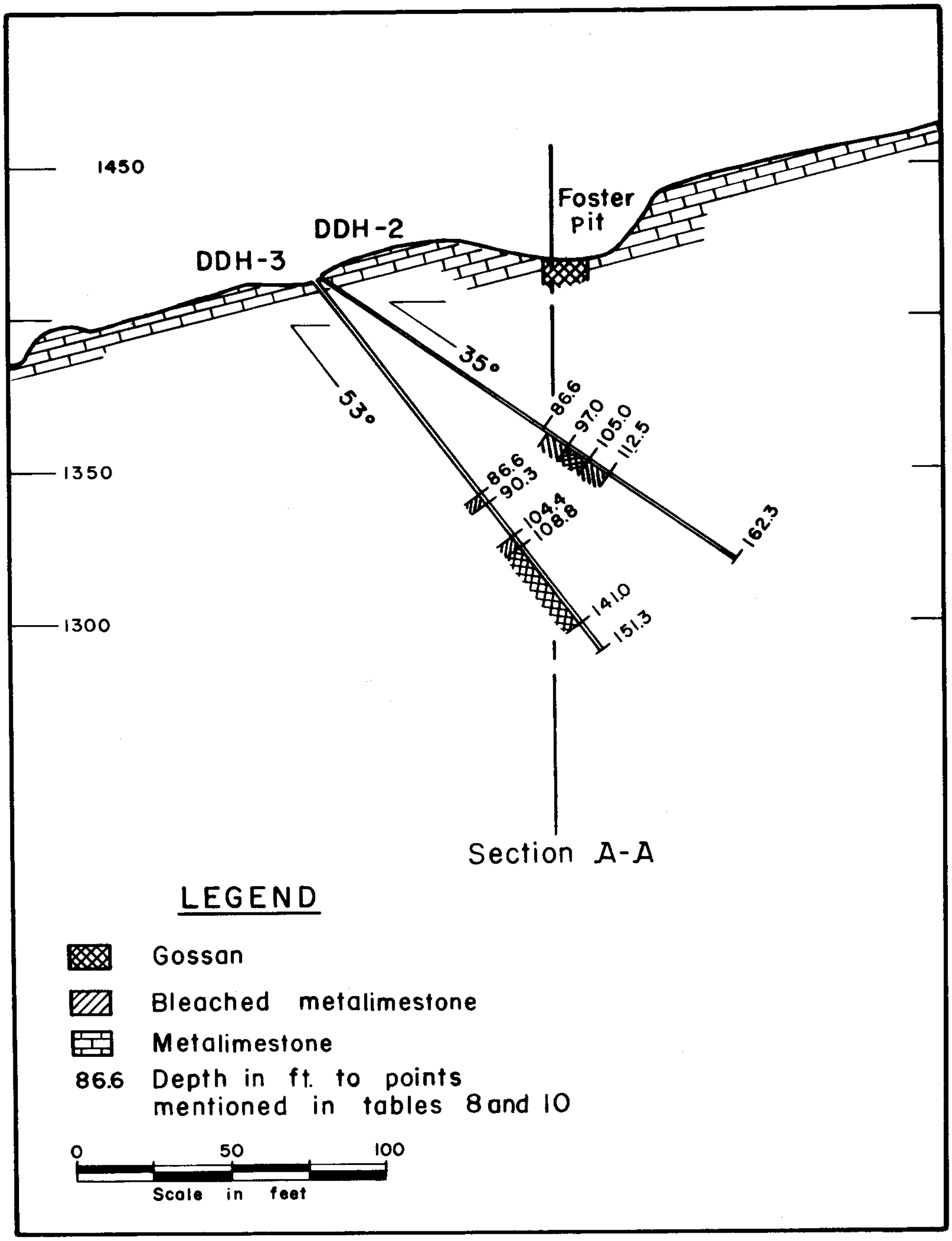

FIGURE 7. - Vertical Section Through Diamond-Drill Holes 2 and 3.

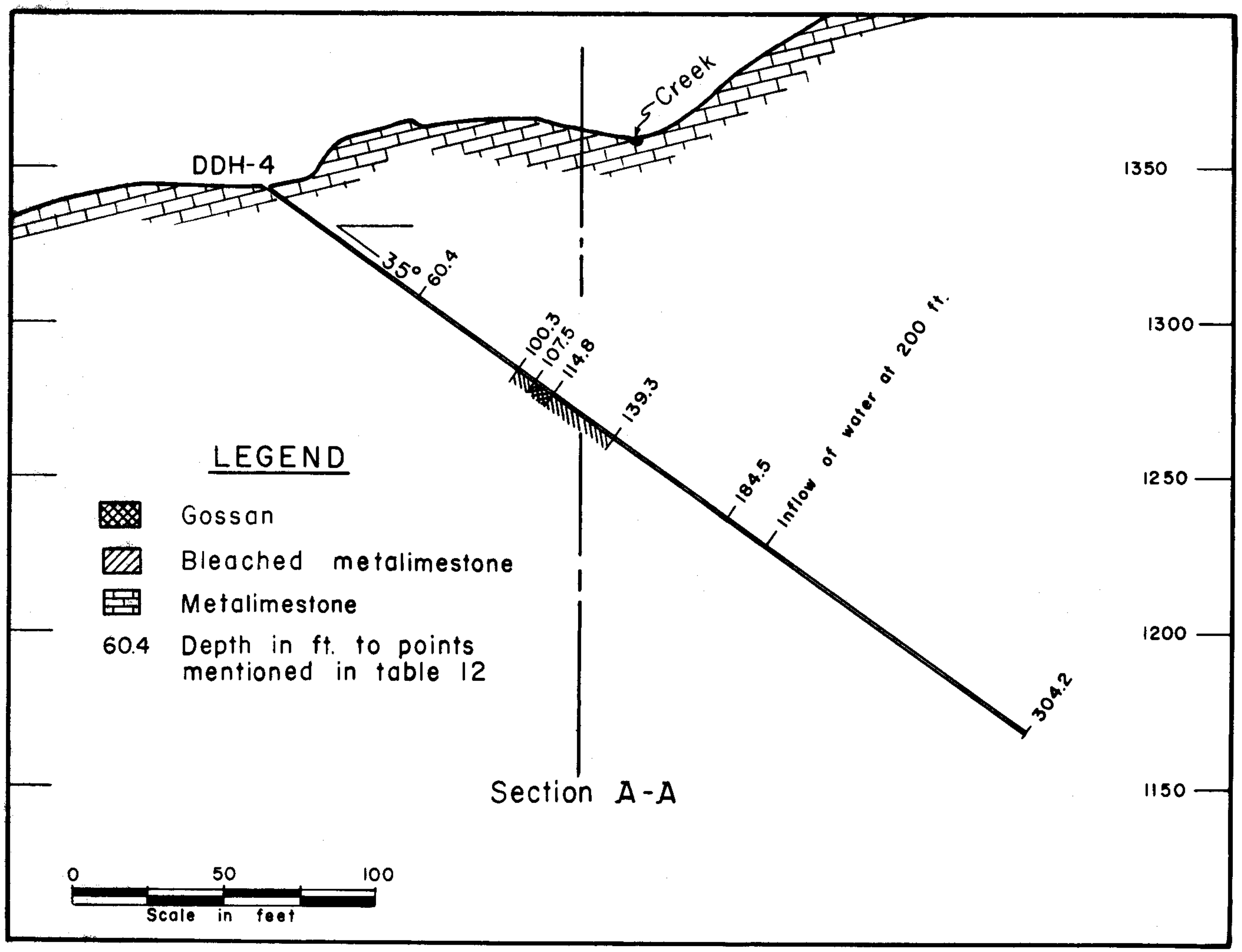

FIGURE 8. - Vertical Section Through Diamond-Drill Hole 4.

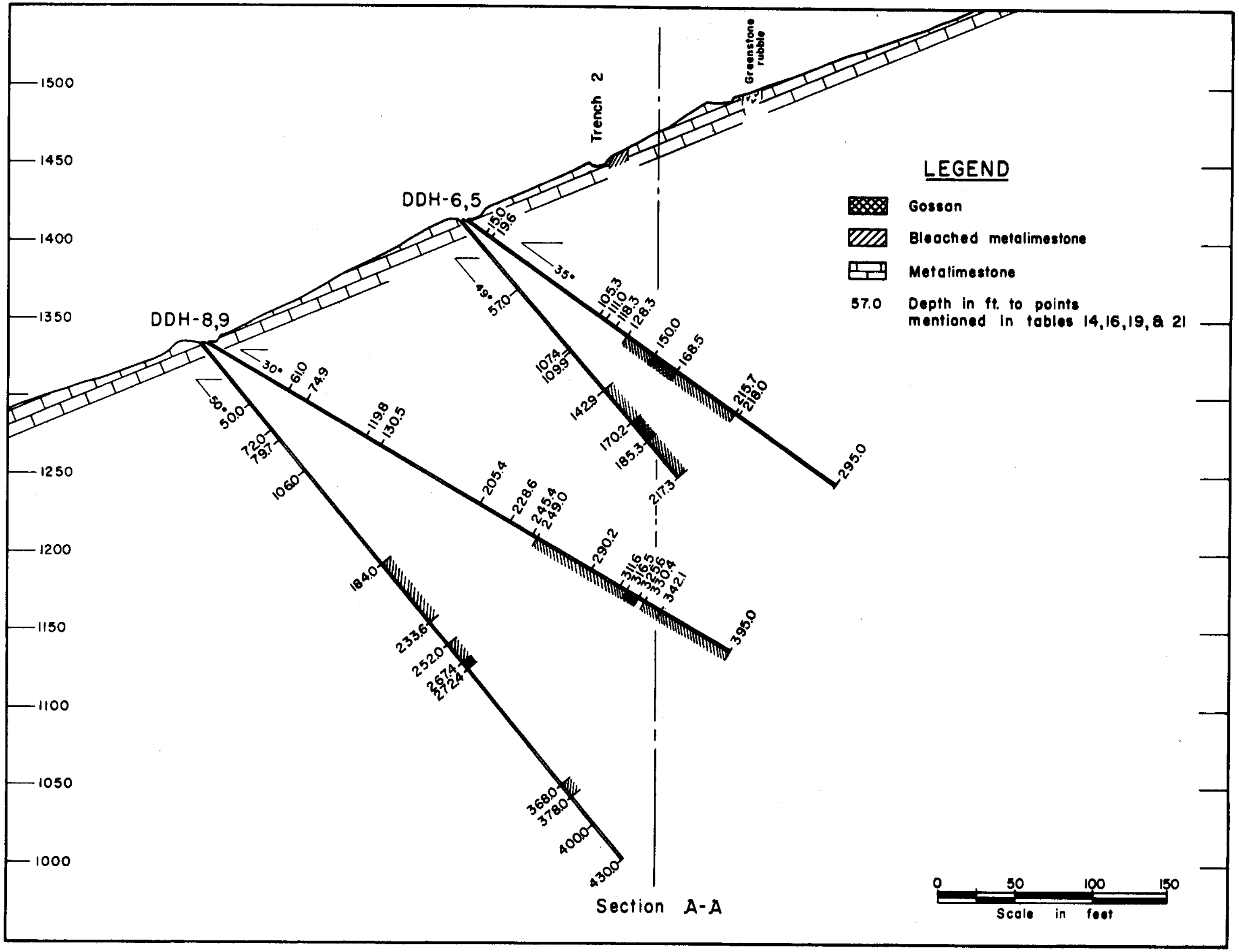

FIGURE 9. - Vertical Section Through Diamond-Drill Holes 5, 6, 8, and 9.

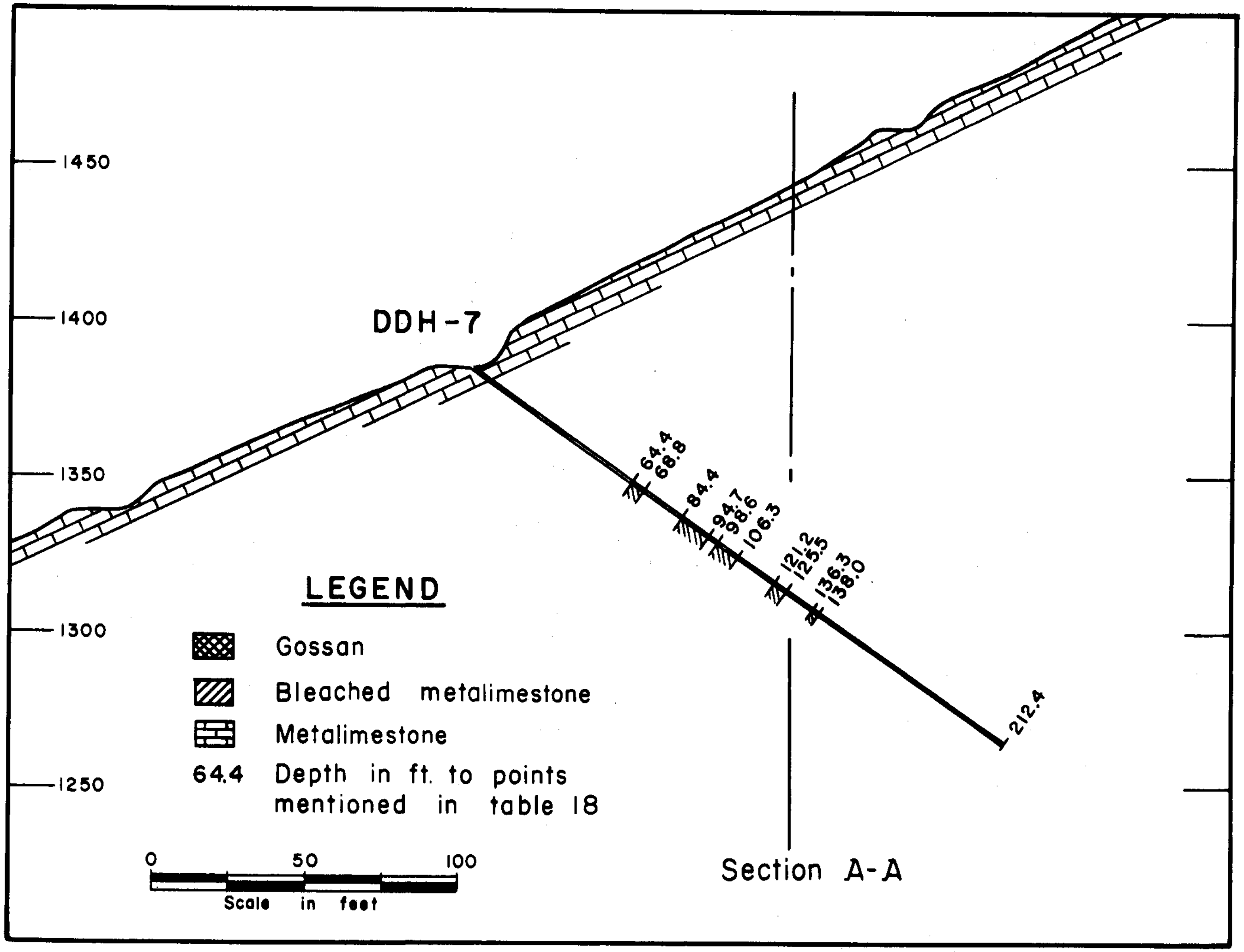

FIGURE 10. - Vertical Section Through Diamond-Drill Hole 7.

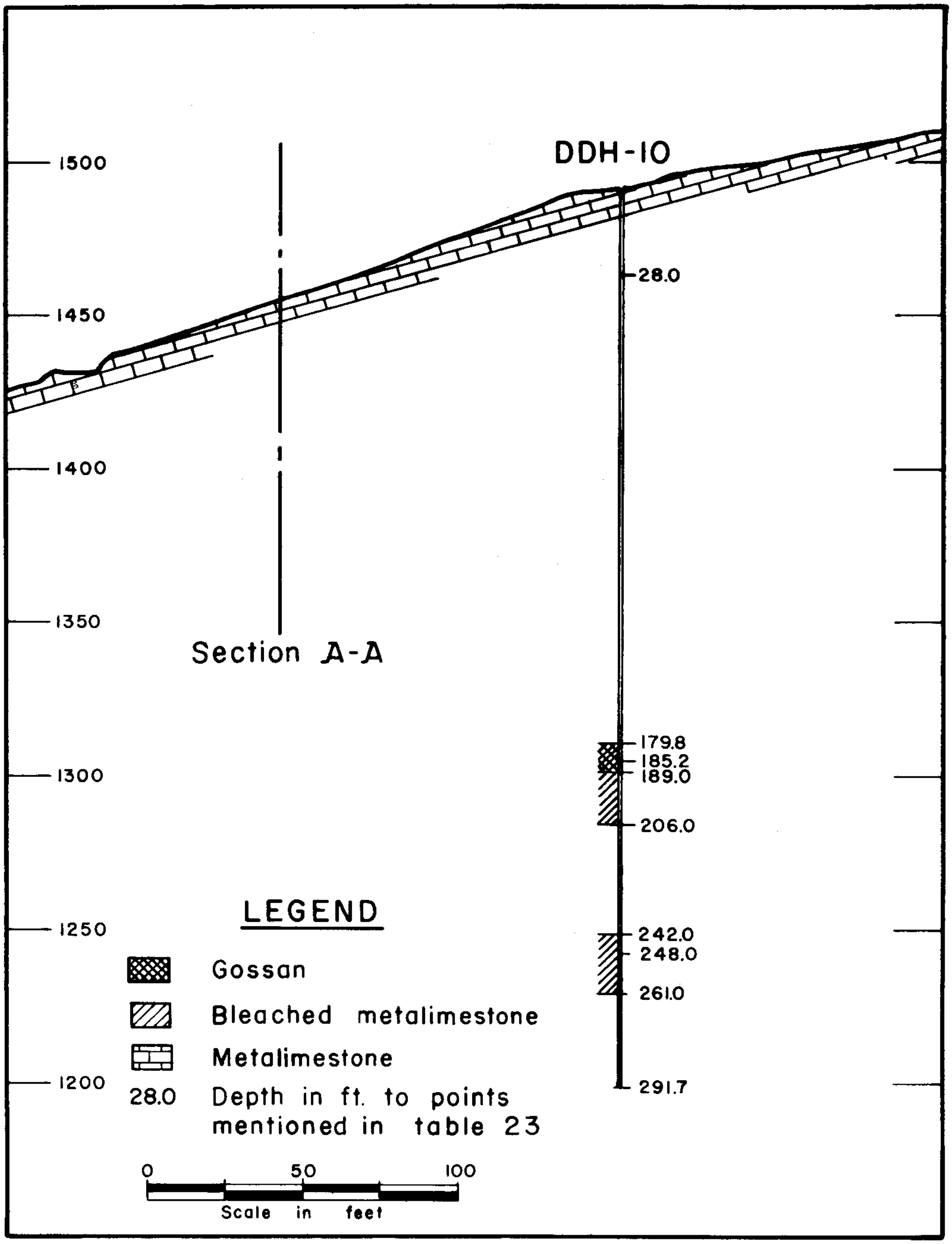

FIGURE 11. - Vertical Section Through Diamond-Drill Hole 10.

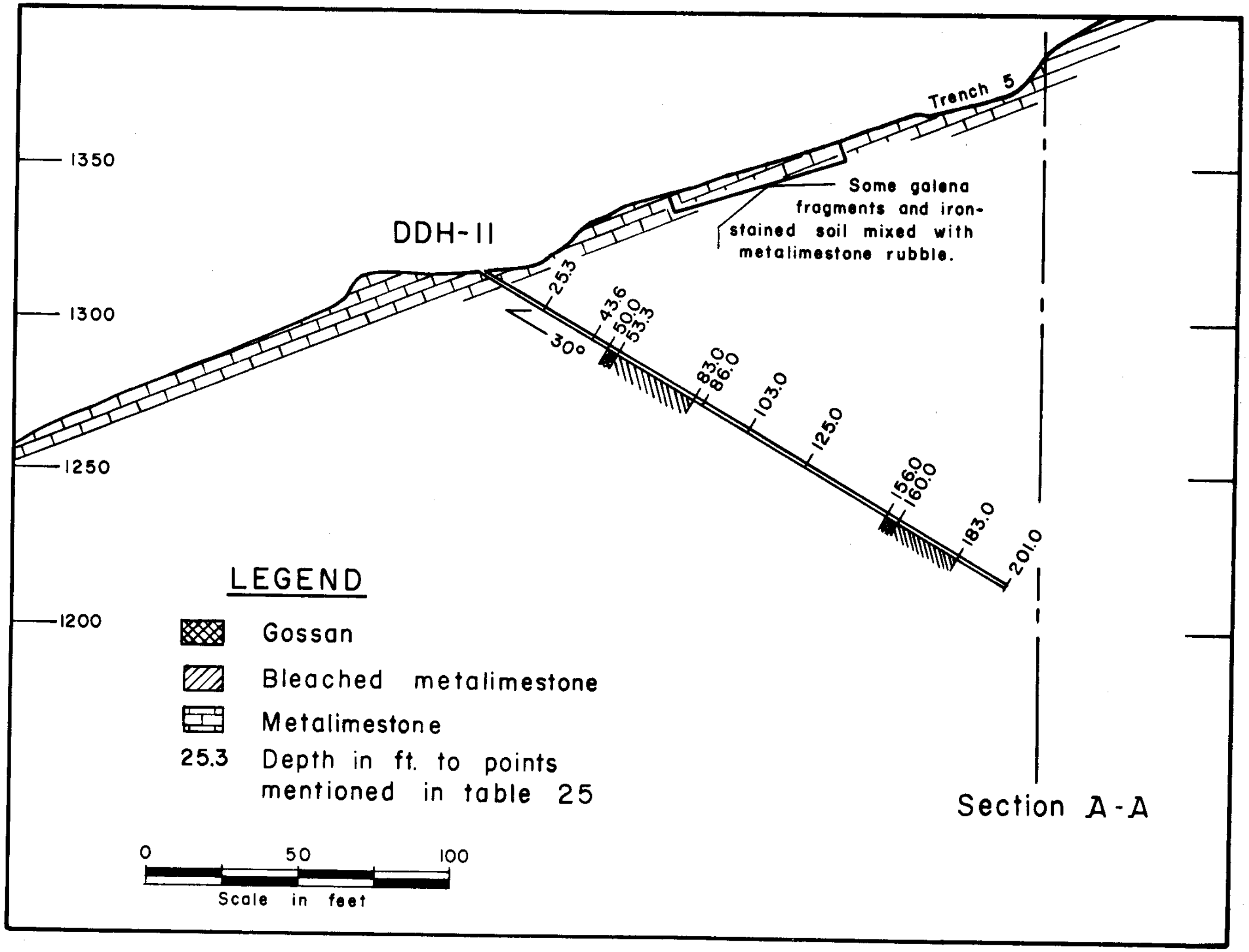

FIGURE 12. - Vertical Section Through Diamond-Drill Hole 11.

TABLE 6. - Diamond-drill-hole log, hole 1[1]

Location: See figures 5 and 6.
Elevation of collar: 1,375 feet.
Depth: 353.6 feet
Dip: -35°.
Bearing: N. 80° E.

Date begun: September 11, 1953
Date finished: September 24, 1953.
Core sizes: BX to 10.0 feet.
AX to 37.4 feet.
EX to 353.6 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	135.2	135.2	82	Broken, fine-grained, gray metalimestone with many small calcite veinlets. Red, yellow, and brown iron staining is prominent on fracture surfaces.
135.2	186.0	50.8	55	Similar broken, gray metalimestone with more numerous iron-stained fractures.
186.0	188.2	2.2	0	Sludge contained metalimestone fragments, quartz grains, clay, and mica.
188.2	207.8	19.6	26	Gossan composed of broken, bleached, silicious metalimestone and brown to red earthy clay. No sulfide minerals were evident.
207.8	208.7	.9	78	Broken bleached silicious metalimestone.
208.7	245.7	37.0	43	Broken, gray metalimestone with iron-stained fractured surfaces.
245.7	255.0	9.3	82	Broken, bleached, iron-stained metalimestone.
255.0	255.5	.5	50	Earthy dark-brown clay.
255.5	307.6	52.1	54	Broken, light-gray metalimestone with yellow to red iron staining on fracture surfaces.
307.6	353.6	46.0	72	Broken, dary-gray metalimestone with very little iron staining.

[1]Analyses data in table 7.

TABLE 7. - Analyses of diamond-drill core samples, hole 1[1] [2]

Footage			Percent				Ounces per ton	
From	To	Distance	Core recovery	Pb	Zn	Fe	Au	Ag
188.2	193.4	5.2	38	0.20	0.34	1.5	0	0.02
193.4	196.4	3.0	17	.10	.20	2.2	([3])	([3])
196.4	199.7	3.3	39	.06	.05	1.5	0	0
199.7	202.9	3.2	12	<.05	.08	.9	([3])	0
202.9	205.6	2.7	15	.09	.20	.5	([3])	.06
205.6	207.8	2.2	18	<.05	<.05	.5	([3])	.04
207.8	208.7	.0	78	.10	<.05	.1	([3])	.01

[1]No sludge samples from this hole.
[2]Spectrographic analyses of a composite of core samples from 188.2 to 208.7 feet:

Al	As	Be	Bi	Sn	Ca	Cu	Pb	Mg	Ag	Zn	Fe	Mn	Ni	Si	Ti	V	B
A	D	E	E	D	A	D+	E	D	F	C	A	D	E	A	E	F	C

Legend:
A - over 10 percent.
B - 5 to 10 percent.
C - 1 to 5 percent.
D - 0.1 to 1 percent.

Legend (Con.):
E - 0.01 to 0.1 percent.
F - 0.001 to 0.01 percent.
G - less than 0.001 percent.

[3]Trace.

TABLE 8. - Diamond-drill-hole log, hole 2

Location: See figures 5 and 7.
Elevation of collar: 1,414 feet.
Depth: 162.3 feet
Dip: -35°.
Bearing: N. 77° E.

Date begun: September 25, 1953.
Date finished: September 29, 1953.
Core sizes: BX to 10.1 feet.
AX to 29.2 feet.
EX to 162.3 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	86.6	86.6	83	Broken, fine-grained, gray metalimestone with a few calcite veinlets and yellow, brown, and red staining on fracture surfaces. A few small fractures contain gray to brown earthy clay.
86.6	89.0	2.4	100	Similar metalimestone with many small fractures filled with yellow-brown clay.
89.0	95.0	6.0	94	Broken metalimestone bleached to a gray-white color.
95.0	97.0	2.0	94	Bleached metalimestone and soft, yellow-brown to chalky-white clay.
[1]97.0	98.2	1.2	42	Iron-stained, bleached metalimestone partly replaced by sulfide minerals.
[1]98.2	105.0	6.8	6	Gossan principally composed of earthy iron-stained clay with some recognizable sulfide minerals including 2 rounded nodules of galena about ½ inch in diameter. The small percentage of recovered core contains hematite, limonite, and bleached silicious limestone.
[1]105.0	108.2	3.2	69	Broken, silicious metalimestone with some sulfide minerals. Fractures contain gossan material.
[1]108.2	112.5	4.3	50	Bleached, iron-stained, broken metalimestone with some gossan material in the fractures.
112.5	162.3	49.8	64	Broken, fine-grained, gray metalimestone with some limonite staining on fracture surfaces.

[1]Analyses data in table 9.

TABLE 9. - Analyses of diamond-drill samples, hole 2

Footage			Sample type	Percent				Ounces per ton	
From	To	Distance		Core recovery	Pb	Zn	Fe	Au	Ag
97.0	98.2	1.2	Core	42	1.60	0.95	30.2	0.03	0.04
98.2	102.7	4.5	-	0	-	-	-	-	-
102.7	105.0	2.3	Core	17	.80	.72	13.8	0	.02
105.0	107.2	2.2	do.	50	.10	<.05	.3	([1])	0
107.2	108.2	1.0	do.	100	.20	.13	.6	([1])	.46
[1]98.2	102.7	-	Sludge	-	2.90	1.40	42.7	([1])	.04
102.7	107.2	-	do.	-	<.05	2.30	32.2	([1])	.01
107.2	112.5	-	do.	-	2.60	1.30	22.2	([1])	.02
112.5	115.9	-	do.	-	.90	.05	5.5	([1])	.17

[1]Trace.
[2]Sludge sample 97.0 to 98.2 feet not recovered.

TABLE 10. - Diamond-drill-hole log, hole 3

Location: See figures 5 and 7.
Elevation of collar: 1,413 feet.
Depth: 151.3 feet.
Dip: -53°.
Bearing: N. 77° E.

Date begun: September 30, 1953.
Date finished: October 9, 1953.
Core sizes: BX to 10.0 feet.
AX to 47.2 feet.
EX to 151.3 feet.

Footage			Core recovery, percent	Formation[1]
From	To	Distance		
0.0	86.6	86.6	83	Broken, fine-grained, gray metalimestone with a few calcite veinlets. Yellow, brown, and bright-red iron minerals form coatings on fracture surfaces and occur in veinlets less than 1/8 inch thick. Openings up to 2 inches across contain earthy, brown to gray clay but show no evidence of alteration by mineralizing solutions.
86.6	90.3	3.7	81	Similar metalimestone with more numerous small fractures and some bleaching along fractures.
90.3	104.4	14.1	74	Gray medium-grained to fine-grained metalimestone with various calcite veinlets 1/16 inch and less across and many iron-stained fractures but no evidence of bleaching.
[2]104.4	108.8	4.4	41	Broken, bleached, iron-stained metalimestone with some clay.
[2]108.8	113.8	5.0	20	Gossan zone consisting chiefly of earthy, iron-stained clay predominately yellow, brown, or red with only traces of sulfide minerals.
[2]113.8	132.6	18.8	76	Gossan zone consisting chiefly of metalimestone largely replaced by goethite, hematite, and limonite and interspersed with yellow to reddish-brown clay. No galena and only traces of other sulfide minerals were observed.
[2]132.6	138.1	5.5	24	Gossan zone consisting of earthy, yellow to brown clay, with limonite and altered limestone fragments.
[2]138.1	141.0	2.9	76	Gossan zone consisting of goethite and limonite grading into bleached, altered metalimestone.
[2]141.0	151.3	10.3	39	Broken gray medium-grained to fine-grained metalimestone with limonite staining on fracture surfaces.

[1]Petrographic analyses of selected specimens of core from hole 3:

20 to 21 feet: Limestone containing minor amounts of limonite, sericite, and traces of kaolinite and carbonaceous matter.

47 feet: Limestone containing minor amounts of sericite, carbonaceous matter, and a trace of limonite.

122 feet: Limestone with minor amounts of associated limonite pseudomorphs, altered feldspar, kaolinite, and carbonaceous matter.

140 feet: Goethite and limonite with minor amounts of associated smithsonite and sericite.

[2]Analyses data in table 11.

TABLE 11. - Analyses of diamond-drill samples, hole 3[1]

Footage			Sample	Percent				Ounces per ton	
From	To	Distance	type	Core recovery	Pb	Zn	Fe	Au	Ag
104.4	108.8	4.4	Core	41	<0.05	<0.05	(2)	(2)	(2)
108.8	113.8	5.0	do.	20	.97	4.55	34.2	0.05	(3)
113.8	122.6	8.8	do.	65	1.06	.47	55.7	.01	0.48
122.6	129.0	6.4	do.	92	.17	<.05	57.2	.43	.26
129.0	132.6	3.6	do.	75	5.00	<.05	50.8	.03	.10
132.6	138.1	5.5	do.	24	.05	<.05	19.4	.01	(3)
138.1	141.0	2.9	do.	76	.10	<.05	2.2	.05	0
141.0	144.0	3.0	do.	67	.10	<.05	2.7	.03	0
144.0	151.3	7.3	do.	27	.05	<.05	(2)	(2)	(2)
104.4	108.8	4.4	Sludge	-	.20	.73	4.3	(3)	0
108.8	113.8	5.0	do.	-	1.17	2.27	39.2	(3)	0
113.8	122.6	8.8	do.	-	.67	.43	56.2	.02	.40
122.6	129.0	6.4	do.	-	1.20	.56	55.1	(3)	.26
129.0	132.6	3.6	do.	-	4.40	.05	48.0	(3)	.16
132.6	138.1	5.5	do.	-	1.17	.47	27.8	(3)	.04
138.1	141.0	2.9	do.	-	.60	.21	4.3	(3)	.05
141.0	144.0	3.0	do.	-	.70	<.05	11.5	(3)	.02
144.0	151.3	7.3	do.	-	.40	.13	2.3	(3)	.01

[1] Spectrographic analyses of a composite of core samples from 108.8 to 141.0 feet:

Al	As	Sn	Ca	Cu	Pb	Mg	Ag	Zn	Cr	Fe	Mn	Ni	Si	Ti	V	Mo	B
D+	D	E	D+	E	A	E	F	C+	E	A	E	F	C	E	F	E	E

Legend:
- A - over 10 percent.
- B - 5 to 10 percent.
- C - 1 to 5 percent.
- D - 0.1 to 1 percent.

Legend (Con.):
- E - 0.01 to 0.1 percent.
- F - 0.001 to 0.01 percent.
- G - less than 0.001 percent.

[2] No assay.
[3] Trace.

TABLE 12. - Diamond-drill-hole log, hole 4

Location: See figures 5 and 8.
Elevation of collar: 1,343 feet.
Depth: 304.2 feet.
Dip: -35°.
Bearing: N. 77° E.

Date begun: May 31, 1954.
Date finished: June 8, 1954.
Core sizes: BX to 10.0 feet.
AX to 101.2 feet.
EX to 304.2 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	60.4	60.4	98	Broken, gray to gray-brown metalimestone with many unoriented calcite veinlets ranging in width from a hairline to ¼ inch and many clay-filled fractures of similar size.
60.4	100.3	39.9	84	Similar metalimestone with more fracturing but no bleaching or other evidence of mineralizing solutions. Most intense fracturing is at 64 feet, 84 feet, 94 feet, 98 feet, and 100 feet.
100.3	107.5	7.2	24	Bleached metalimestone with some iron-stained clay.
[1]107.5	114.8	7.3	22	Gossan zone consisting principally of iron-stained earthy clay and brown fragments of altered metalimestone.
114.8	139.3	24.5	47	Broken, gray metalimestone with much iron stain and some bleaching.
139.3	184.5	45.2	22	Intensely broken, gray metalimestone with some iron stain on fracture surfaces.
184.5	304.2	119.7	30	Broken, dark-gray metalimestone with little iron stain and no evidence of mineralizing solutions. Many unoriented fractures make this rock almost impossible to core.

[1]Analyses data in table 13.

TABLE 13. - Analyses of diamond-drill samples, hole 4[1]

Footage			Sample type	Percent			
From	To	Distance		Core recovery	Pb	Zn	Fe
107.5	109.8	2.3	Core	9	<0.05	0.20	1.7
109.8	111.2	1.4	do.	57	<.05	<.05	1.7
111.2	113.0	1.8	do.	17	<.05	<.05	1.6
113.0	114.8	1.8	do.	17	<.05	.05	4.5
94.1	101.2	7.1	Sludge	-	.10	.10	4.6
101.2	107.5	6.3	do.	-	.10	.10	1.5
107.5	109.8	2.3	do.	-	<.05	.10	5.3
109.8	111.2	1.4	do.	-	<.05	<.05	2.9
111.2	115.6	4.4	do.	-	.10	.05	5.0

[1]No assay for Au and Ag.

TABLE 14. - Diamond-drill-hole log, hole 5

Location: See figures 5 and 9.
Elevation of collar: 1,414 feet.
Depth: 295.0 feet.
Dip: -35°.
Bearing: N. 79° 30' E.

Date begun: June 9, 1954.
Date finished: June 18, 1954.
Core sizes: BX to 15.0 feet.
AX to 150.7 feet.
EX to 295.0 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	15.0	15.0	83	Broken, gray, fine-grained metalimestone with red and yellow staining on fracture surfaces.
15.0	19.6	4.6	78	Quartz-mica schist in sludge but not recovered in core, which is similar to core from 0 to 15 feet.
19.6	105.3	85.7	76	Broken, gray, fine-grained metalimestone with red and yellow iron staining on fracture surfaces and some small mud-filled fractures.
105.3	111.0	5.7	90	Gray metalimestone with pale-red to light-brown bands.
111.0	118.3	7.3	97	Gray, fine-grained metalimestone.
118.3	128.3	10.0	64	Quartz-mica schist fragments recovered in sludge but not in core, which is similar to core from 111.0 to 118.3 feet.
128.3	150.0	21.7	59	Broken, gray metalimestone with many fractures and small solution cavities. Bleaching is prominent near some fracture surfaces.
[1] [2] 150.0	168.5	18.5	17	Gossan composed principally of red, yellow, and brown earthy iron oxides mixed with cerussite and fragments of altered limestone, goethite, hematite, and limonite. Small bands of galena and traces of other sulfides occur in the solid fragments.
168.5	215.7	47.2	59	Broken, gray metalimestone with bleaching evident along some fractures and iron staining on fracture surfaces.
215.7	218.0	2.3	9	Fracture zone with brown mud and some red hematite fracture filling but no evidence of sulfide minerals and no bleaching of the metalimestone.
218.0	295.0	77.0	65	Broken, fine-grained, gray metalimestone.

[1] Petrographic analyses of sludge samples from 162.9 to 167.8 feet: Chiefly limonite with some cerussite; tin and traces of zinc were present, but the minerals could not be identified.

[2] Analyses data in table 15.

TABLE 15. - Analyses of diamond-drill samples, hole 5

Footage			Sample type	Percent				Ounces per ton	
From	To	Distance		Core recovery	Pb	Zn	Fe	Au	Ag
150.0	155.8	5.8	Core	9	3.00	<0.05	19.9	<0.02	0.02
155.8	159.6	3.8	do.	12	2.90	<.05	55.5	<.02	.54
159.6	168.5	8.9	do.	28	([1])				
146.8	153.3	6.5	Sludge	-	.90	<.05	8.2	<.02	.20
153.3	155.8	2.5	do.	-	11.20	<.05	37.8	<.02	1.29
155.8	159.6	3.8	do.	-	7.10	<.05	50.8	<.02	.60
159.6	162.9	3.3	do.	-	4.05	.05	54.6	<.02	.28
162.9	167.8	4.9	do.	-	21.10	.17	39.0	<.02	10.02
167.8	170.3	2.5	do.	-	2.50	.10	5.8	<.02	1.28

[1] Sample lost.

TABLE 16. - Diamond-drill-hole log, hole 6

Location: See figures 5 and 9.
Elevation of collar: 1,414 feet.
Depth: 217.3 feet.
Dip: -49°.
Bearing: N. 79° 30' E.

Date begun: June 18, 1954.
Date finished: June 28, 1954.
Core sizes: BX to 57.0 feet.
AX to 138.7 feet.
EX to 217.3 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	57.0	57.0	74	Broken, iron-stained, gray to red-gray metalimestone with calcite veinlets and many small mud-filled fractures.
57.0	107.4	50.4	35	Intensely broken, gray, medium-grained metalimestone with yellow to red staining on fracture surfaces.
107.4	109.9	2.5	32	Quartz-mica schist fragments in sludge but core similar to core from 57.0 to 107.4 feet.
109.9	142.9	33.0	66	Broken, gray metalimestone with many small clay-filled fractures.
142.9	170.2	27.3	63	Broken, bleached metalimestone with yellow to red clay in many small fractures.
[1]170.2	185.3	15.1	41	Gossan composed principally of brown to red earthy iron oxides with clay, altered metalimestone, hematite, goethite and limonite.
185.3	217.3	32.0	43	Broken, gray metalimestone with some bleaching along minor fractures. A clay-filled opening (possibly a solution cavity) encountered at 197 feet showed no evidence of mineralizing solutions.

[1]Analyses data in table 17.

TABLE 17. - Analyses of diamond-drill samples, hole 6[1]

Footage			Sample type	Percent			
From	To	Distance		Core recovery	Pb	Zn	Fe
170.2	172.9	2.7	Core	22	0.47	<0.05	50.0
172.9	177.5	4.6	do.	56	.36	<.05	58.5
177.5	179.2	1.7	do.	59	.20	<.05	58.0
179.2	184.0	4.8	do.	27	.78	<.05	54.8
184.0	185.3	1.3	do.	53	.71	<.05	16.6
170.2	172.9	2.7	Sludge	-	.44	<.05	54.0
172.9	177.5	4.6	do.	-	.45	.07	57.3
177.5	179.2	1.7	do.	-	.93	.10	57.9
179.2	184.0	4.8	do.	-	.48	.10	57.4
184.0	185.3	1.3	do.	-	.65	.10	40.6
185.3	188.3	3.0	do.	-	<.05	.05	4.8
188.3	193.4	5.1	do.	-	<.05	.10	1.1

[1]No assay for Au and Ag.

TABLE 18. - Diamond-drill-hole log, hole 7[1]

Location: See figures 5 and 10.
Elevation of collar: 1,385 feet.
Depth: 212.4 feet.
Dip: -35°.
Bearing: N. 70° E.

Date begun: June 29, 1954.
Date finished: July 7, 1954.
Core sizes: BX to 65 feet.
AX to 212.4 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	64.4	64.4	90	Iron-stained, gray to red-gray metalimestone with calcite veinlets and many small mud-filled fractures.
64.4	68.8	4.4	100	Similar metalimestone with some red hematite and clay in fractures and some bleaching along fractures.
68.8	84.4	15.6	96	Gray, fine-grained to medium-grained metalimestone with small mud-filled fractures.
84.4	94.7	10.3	84	Broken, gray metalimestone with some bleaching along fractures.
94.7	98.6	3.9	97	Gray, fine-grained to medium-grained metalimestone.
98.6	106.3	7.7	99	Similar metalimestone with some bleaching along minor fractures.
106.3	121.2	14.9	89	Broken, dark-gray metalimestone with small clay-filled fractures.
121.2	125.5	4.3	88	Similarly broken dark-gray metalimestone with traces of bleaching along minor fractures.
125.5	136.3	10.8	96	Broken, dark-gray metalimestone. Some micaceous fragments recovered in sludge but not in core.
136.3	138.0	1.7	99	Similar metalimestone with traces of bleaching along fractures.
138.0	212.4	74.4	93	Gray, fine-grained to medium-grained metalimestone with small calcite veinlets and many small clay-filled fractures. An open cavity, possibly a solution channel, was encountered at 169 feet, and a zone of intense fracturing extended from 200 to 212 feet. There was no gossan material nor evidence of mineralizing solutions.

[1]No samples from this hole were assayed.

TABLE 19. - Diamond-drill hole log, hole 8

Location: See figures 5 and 9.
Elevation of collar: 1,334 feet.
Depth: 430.0 feet.
Dip: -50°.
Bearing: N. 79° 30' E.

Date begun: July 8, 1954
Date finished: July 22, 1954.
Core sizes: BX to 79.7 feet.
AX to 217.9 feet.
EX to 430.0 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	50.0	50.0	66	Broken, fine-grained, gray metalimestone with few calcite veinlets and numerous small clay-filled fractures.
50.0	72.0	22.0	67	Intensely weathered and broken, gray metalimestones with more numerous small clay-filled fractures.
72.0	79.7	7.7	32	Fracture zone with clay-filled openings over 1 foot across but no evidence of mineralizing solutions.
79.7	106.0	26.3	81	Broken, fine-grained, gray metalimestone with small clay-filled fractures.
106.0	184.0	78.0	80	Broken, fine-grained, gray metalimestone with small clay-filled fractures. Quartz and mica were recovered in the sludge but not in the core.
184.0	233.6	49.6	61	Broken metalimestone with bleaching along fractures and much iron stain.
233.6	252.0	19.4	82	Broken, fine-grained gray metalimestone with a few small clay-filled fractures.
252.0	267.4	15.4	82	Broken, bleached metalimestone with considerable iron stain.
[1]267.4	269.0	1.6	80	Gossan composed of altered metalimestone partially replaced by iron oxides but no sulfide minerals.
269.0	272.4	3.4	60	Broken, bleached metalimestone with some gossan material in fractures.
272.4	368.0	95.6	55	Broken, gray metalimestone with many fractures and voids. Some fractures and voids are clay filled; some contain only ice, and some are open. Water was lost frequently while drilling.
368.0	378.0	10.0	50	Bleached metalimestone with some iron-stained clay in many small fractures.
378.0	400.0	22.0	49	Broken, gray metalimestone with many ice-filled and clay-filled fractures.
400.0	430.0	30.0	49	Intensely broken, gray metalimestone with considerable brown clay in fractures but no ice or other evidence of permafrost. The metalimestone and the fracture filling is essentially similar to that on the surface both in original form and degree of weathering.

[1]Analyses data in table 20.

TABLE 20. - Analyses of diamond-drill samples, hole 8[1]

Footage			Sample type	Percent			
From	To	Distance		Core recovery	Pb	Zn	Fe
267.4	269.0	1.6	Core	80	0.06	<0.05	6.4
267.4	272.4	5.0	Sludge	-	.05	.02	4.5

[1]No assay for Au and Ag.

TABLE 21. - Diamond-drill-hole log, hole 9

Location: See figures 5 and 9.
Elevation of collar: 1,334 feet.
Depth: 395.0 feet.
Dip: -30°.
Bearing: N. 79° 30' E.

Date begun: July 23, 1954.
Date finished: August 5, 1954.
Core sizes: BX to 80.7 feet.
AX to 205.4 feet.
EX to 395.0 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	61.0	61.0	71	Broken, fine-grained, gray metalimestone with a few calcite veinlets and small clay-filled fractures.
61.0	74.9	13.9	67	Similar, broken, fine-grained, gray metalimestone with more clay-filled fractures; quartz and mica in the sludge but not in the core.
74.9	88.0	13.1	38	Broken, fine-grained, gray metalimestone with numerous clay-filled fractures and voids.
88.0	119.8	31.8	76	Broken, gray to red-brown metalimestone with occasional small clay-filled fractures.
119.8	130.5	10.7	64	Broken, gray metalimestone; quartz and mica fragments in the sludge but not in the core.
130.5	205.4	74.9	87	Broken, gray metalimestone with some small clay-filled fractures.
205.4	228.6	23.2	50	Intensely broken, gray metalimestone with many fractures and voids containing clay, mica, quartz grains, and ice.
228.6	245.4	16.8	88	Broken, gray metalimestone.
245.4	249.0	3.6	36	Broken, gray metalimestone with several voids. Sludge contained a large percentage of quartz and mica mixed with brown, earthy clay.
249.0	290.2	41.2	44	Broken, gray metalimestone with some bleaching along minor fractures.
290.2	311.6	21.4	74	Broken, gray metalimestone with more intense bleaching along fracture surfaces.
311.6	316.5	4.9	86	Intensely bleached metalimestone with some gossan material in fractures.
[1]316.5	325.6	9.1	40	Gossan zone composed of clay, earthy iron oxides and altered metalimestone partially replaced by iron oxides but no sulfide minerals.
325.6	330.4	4.8	85	Broken, gray metalimestone.
330.4	342.1	11.7	22	Broken, bleached metalimestone with large voids. Sludge samples were lost. The color of occasional small amounts of return water indicated that the voids contained iron oxides. No metallic minerals were evident in the core.
342.1	395.0	52.9	29	Intensely broken metalimestone with bleaching on fracture surfaces. Sludge could not be recovered owing to the porous nature of the rock. The color of the occasional small amounts of return water did not indicate the presence of metallic minerals.

[1]Analyses data in table 22.

TABLE 22. - Analyses of diamond-drill sludge samples, hole 9[1]

Footage			Percent			
From	To	Distance	Core recovery	Pb	Zn	Fe
316.5	319.6	3.1	42	<0.05	0.05	3.9
319.6	321.9	2.3	17	<.05	.20	8.0
321.9	323.6	1.7	53	<.05	.20	5.9
323.6	325.6	2.0	50	<.05	<.05	3.7

[1] No assay for Au and Ag.

TABLE 23. - Diamond-drill-hole log, hole 10

Location: See figures 5 and 11.
Elevation of collar: 1,491 feet.
Depth: 291.4 feet.
Dip: Vertical.

Date begun: August 6, 1954.
Date finished: August 20, 1954.
Core sizes: BX to 40.0 feet.
AX to 189.0 feet.
EX to 291.7 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	28.0	28.0	71	Intensity broken, gray, fine-grained metalimestone with some small calcite veinlets and some brown to yellow stain and clay in small fractures.
28.0	29.0	1.0	0	Mica and clay recovered in sludge.
29.0	179.8	150.8	84	Broken, gray, fine-grained metalimestone with some small calcite veinlets and some red and brown iron stain on fracture surfaces.
[1] 179.8	185.2	5.4	40	Gossan zone composed of altered metalimestone, clay, ice, and earthy iron oxides.
185.2	189.0	3.8	46	Intensely broken and partially bleached metalimestone with some gossan material in fractures.
189.0	206.0	17.0	74	Broken, gray metalimestone with some bleaching along fracture surfaces.
206.0	242.0	36.0	53	Broken, gray metalimestone.
242.0	248.0	6.0	52	Bleached, altered metalimestone with some iron-stained clay in fractures.
248.0	261.0	13.0	81	Broken, gray metalimestone with some bleaching and iron-staining along fracture surfaces.
261.0	291.7	30.7	46	Intensely broken, dark-gray to nearly black metalimestone.

[1] Analyses data in table 24.

TABLE 24. - Analyses of diamond-drill samples, hole 10[1]

Footage			Sample type	Percent			
From	To	Distance		Core recovery	Pb	Zn	Fe
180.4	185.2	4.8	Core	40	<0.05	<0.05	6.7
179.8	182.1	2.3	Sludge	-	<.05	<.05	5.5
182.1	184.7	2.6	do.	-	<.05	<.05	5.9
184.7	185.7	1.0	do.	-	.05	.05	7.6
185.7	188.2	2.5	do.	-	<.05	<.05	3.5

[1] No assay for Au and Ag.

TABLE 25. - Diamond-drill-hole log, hole 11[1]

Location: See figures 5 and 12.
Elevation of collar: 1,316 feet.
Depth: 201.0 feet.
Dip: -30°.
Bearing: N. 78° E.

Date begun: August 21, 1954.
Date finished: August 31, 1954
Core sizes: BX to 56 feet.
AX to 136 feet.
EX to 201 feet.

Footage			Core recovery, percent	Formation
From	To	Distance		
0.0	25.3	25.3	51	Intensely broken, iron-stained, gray metalimestone.
25.3	27.2	1.9	0	Sludge contained clay, altered metalimestone fragments, and iron oxides.
27.2	43.6	16.4	61	Intensely broken, iron-stained, gray metalimestone.
43.6	45.1	1.5	0	Sludge contained metalimestone fragments and iron-stained clay.
45.1	50.0	4.9	41	Broken, gray metalimestone with a few calcite veinlets and iron-stained fractures.
50.0	53.3	3.3	0	Sludge contained metalimestone fragments and iron-stained clay.
53.3	83.0	29.7	71	Broken, gray metalimestone with a little bleaching along fractures.
83.0	83.5	.5	0	Sludge contained metalimestone fragments, mica, and clay.
83.5	86.0	2.5	72	Broken, gray metalimestone.
86.0	88.0	2.0	0	Sludge contained metalimestone fragments, mica, and clay.
88.0	103.0	15.0	80	Broken, gray metalimestone.
103.0	107.0	4.0	10	Broken, gray metalimestone in core; clay and mica in sludge.
107.0	125.0	18.0	72	Broken, gray metalimestone.
125.0	127.0	2.0	0	Sludge contained quartz sand, mica, clay, and metalimestone fragments.
127.0	156.0	29.0	81	Broken, gray metalimestone with a little iron staining on fracture surfaces.
156.0	160.0	4.0	45	Bleached metalimestone with some clay and earthy iron oxides.
160.0	183.0	23.0	77	Broken, gray metalimestone with a little bleaching along fracture surfaces.
183.0	201.0	18.0	83	Broken, gray to black metalimestone.

[1]No samples from this hole were assayed.

TABLE 26. - Average grade of gossan deposit in diamond-drill holes 2, 3, 5, and 6

Hole number	Footage		Sample type	Horizontal width of gossan	Percent[1]				Ounces per ton[1]
	From	To			Core recovery	Pb	Zn	Fe	Ag
DDH-2	97.0	105.0	Core	6.6	11	1.07	0.80	19.4	0.03
DDH-3	108.8	141.0	do.	19.3	58	1.05	.83	41.1	.19
DDH-5	150.0	168.5	do.	15.1	10	2.96	<.05	34.0	.23
DDH-6	170.2	185.3	do.	9.9	41	.52	<.05	52.1	([2])
Average DDH-2, 3, 5, and 6...........			Core	12.7	34	1.52	.42	38.3	
DDH-2	[3]98.2	105.0	Sludge	5.6	-	1.91	1.70	39.2	.03
DDH-3	108.8	141.0	do.	19.3	-	1.35	.69	42.9	.65
DDH-5	150.0	168.5	do.	15.1	-	9.54	.06	37.3	3.08
DDH-6	170.2	185.3	do.	9.9	-	.53	.07	55.4	([2])
Average DDH-2, 3, 5, and 6...........			Sludge	-	-	3.73	.49	43.3	

[1] Weighted only in proportion to the horizontal width represented. Core and sludge analyses are tabulated separately because little of the soft earthy material was recovered as core.

[2] No assay.

[3] Sludge sample 97.0 to 98.2 feet not recovered.

Interpretations

Analyses of the samples from the diamond-drill holes and bulldozer trenches indicate that the deposit occurs roughly in three zones.

The uppermost zone has traces of bleaching and gossan material is relatively unbroken metalimestones. Diamond-drill hole 7 is entirely within this zone, which also is exposed in the northwest end of the Foster pit and in trench 2.

The middle zone is a pod or possibly pipe-like body of gossan that was formed in broken metalimestone and appears to pitch to the north-northwest at approximately the local dip of the metasediments--25 to 35 degrees. This body is exposed in the Foster pit and cut by diamond-drill holes 2, 3, 5, and 6. An abundance of galena nodules was found in the Foster pit, but no massive galena was recovered as core and only a few small fragments were found in the sludge samples. The drill-hole samples contained principally clay, limonite, goethite, cerussite, anglesite, and quartz in a soft, earthy deposit, interspersed with hard zones of partly replaced silicified metalimestone. Table 26 is a computation of the average grade of core and sludge samples recovered from this zone.

The third and lowest zone is characterized by intense fracturing, widespread bleaching of the metalimestones, lesser amounts of gossan in apparently discontinuous openings, and the almost complete absence of sulfide minerals. Diamond-drill holes 1, 4, 8, 9, and 11 penetrated this zone.

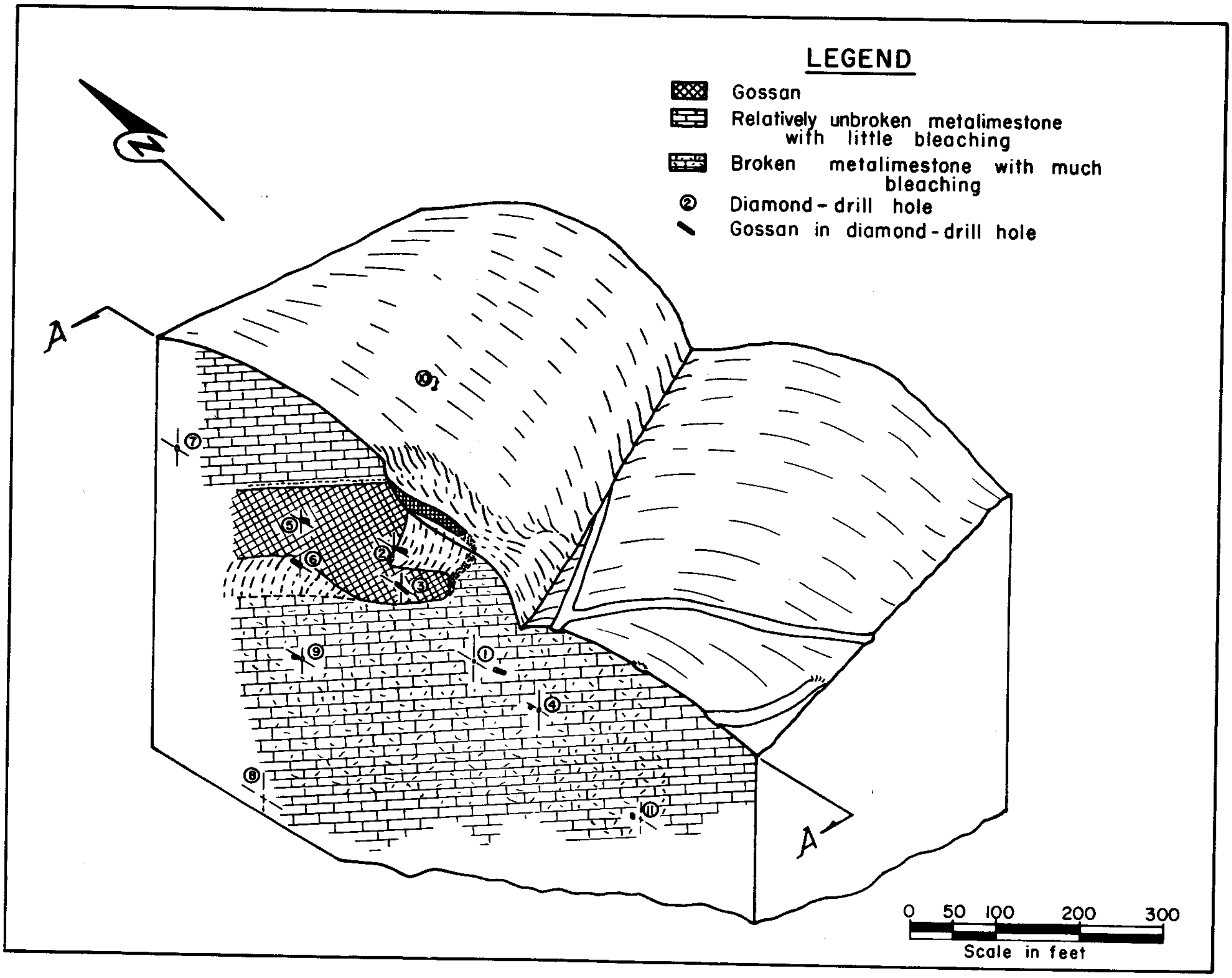

FIGURE 13. - Vertical Longitudinal Section on A-A, Foster Prospect.

Diamond-drill hole 10 was drilled vertically to determine if the mineralizing solutions had followed bedding planes or other openings to form deposits extending northward from the outcrop. Little evidence of mineralizing solutions and only traces of gossan material were found.

The zonal nature of the deposit and the penetration point of the various drill holes is illustrated in figure 13.

Accessory Metals and Minerals

Gold and Silver

Gold is present in much of the gossan material. The grade ordinarily ranges from a trace to 0.05 ounce per ton. Silver is present in amounts usually ranging from 0.2 to 0.4 ounce per ton per percent lead. Silver usually was more abundant in the less altered samples.

Table 27 is a summary of the silver-lead ratios of samples from Foster pit and diamond-drill holes.

TABLE 27. - Average silver-lead ratio of samples, Foster prospect[1]

Location	From feet	To feet	Type	Pb, percent	Ag, ounces per ton	Silver, ounces per ton per percent lead
DDH-2..........	97.0	98.2	Core	1.60	0.04	0.02
DDH-2..........	98.2	102.7	Sludge	2.90	.04	.01
DDH-2..........	107.2	112.5	do.	2.60	.02	.01
DDH-3..........	113.8	122.6	Core	1.07	.48	.45
DDH-3..........	129.0	132.6	do.	5.00	.10	.02
DDH-3..........	108.8	113.8	Sludge	1.17	-	-
DDH-3..........	122.6	129.0	do.	1.20	.26	.22
DDH-3..........	129.0	132.6	do.	4.40	.16	.04
DDH-3..........	132.6	138.1	do.	1.17	.04	.03
DDH-5..........	150.0	155.8	Core	3.00	.02	.01
DDH-5..........	155.8	159.6	do.	2.90	.54	.19
DDH-5..........	153.3	155.8	Sludge	11.20	1.29	.12
DDH-5..........	155.8	159.6	do.	7.10	.60	.08
DDH-5..........	159.6	162.9	do.	4.05	.28	.07
DDH-5..........	162.9	167.8	do.	21.10	10.02	.47
DDH-5..........	167.8	170.3	do.	2.50	1.28	.51
Total.......	-	-	-	72.95	15.17	-

Average: $\frac{15.17}{72.95}$ = 0.21 ounce silver per ton per percent lead.

Foster pit:				
Sample No. 3...............	Channel	9.5	1.40	0.15
Sample No. 4...............	do.	22.1	5.68	.26
Sample No. 5...............	do.	6.8	2.75	.40
Sample No. 7...............	do.	11.6	4.74	.41
Sample No. 8...............	do.	25.6	14.90	.58
Total..................	-	75.6	29.47	-

Average: $\frac{29.47}{75.6}$ = 0.39 ounce silver per ton per percent lead.

[1] Foster pit channel samples containing less than 5 percent lead are not included; however, because of the generally lower grades, all diamond-drill samples containing more than 1 percent lead are included.

Tin

Tin, in amounts ranging from a trace to 0.3 percent, occurs irregularly distributed through the gossan at the Foster prospect, apparently associated with the lead minerals. The tin mineral or minerals could not be isolated or identified. Analyses are presented in table 28. Tin also occurs with lead minerals at the Omilak mine (table 31).

The discovery of tin in these deposits considerably extends the area of known tin deposition and suggests that tin deposits may be associated with the large granitic intrusives that outcrop to the east.

TABLE 28. - Analysis of samples for tin[1]

Location	From feet	To feet	Type	Sn, percent
DDH-2	102.7	105.0	Core	0.10
DDH-2	98.2	102.7	Sludge	.10
DDH-3	122.6	132.6	Core	.08
DDH-3	127.3	129.0	Sludge	.08
DDH-5	150.0	155.8	Core	.09
DDH-5	155.8	159.6	do.	.06
DDH-5	146.8	153.3	Sludge	.06
DDH-5	153.3	155.8	do.	.12
DDH-5	155.8	159.6	do.	.09
DDH-5	159.6	162.9	do.	.06
DDH-5	162.9	167.8	do.	.32
DDH-5	167.8	170.3	do.	.06
DDH-6	170.2	172.9	Core	.06
Foster pit:				
Sample No. 3	-	-	Channel	.10
Sample No. 4	-	-	do.	.30
Sample No. 5	-	-	do.	.10
Sample No. 7	-	-	do.	.10
Sample No. 8	-	-	do.	.20
Sample No. 9	-	-	Specimen	.20

[1]The tin content of samples from diamond-drill holes 1, 2, 3, 5, and 6 and Foster pit samples 1 through 9 was determined by chemical analyses; only samples having over 0.05 percent tin are listed. Spectrographic analyses of selected specimens indicated that samples containing measurable amounts of lead usually contain at least traces of tin.

Copper

Copper, in amounts ranging from barely perceptable traces to a maximum of 0.1 percent, is distributed throughout the gossan material. However, the only identifiable copper minerals were found in the Foster pit where traces of copper oxides and small amounts of copper sulfides (principally chalcopyrite) occur associated with arsenopyrite, pyrite, and quartz as segregations encased in relatively unoxidized massive galena nodules. The copper content of almost all samples was checked, but the results were not tabulated because the grade was uniformly low.

Antimony

The presence of small amounts of antimony in the gossan at the Foster prospect was verified by chemical and spectrographic analyses, but no visually identifiable antimony mineral was noted either in the diamond-drill cores or in the surface samples. Analyses are presented in table 29. Stibnite is associated with galena at the Omilak mine (table 31).

TABLE 29. - Antimony analyses of samples[1]

Location	Type	Sb, percent
DDH-2[2]	Core	0.60
Foster pit:		
Sample No. 1	Channel	.10
Sample No. 2	do.	.10
Sample No. 3	do.	.30
Sample No. 4	do.	.20
Sample No. 5	do.	.20
Sample No. 6	do.	.10
Sample No. 7	do.	.20
Sample No. 8	do.	.10
Sample No. 9	Specimen	.20

[1] The antimony content of samples from diamond-drill holes 1, 2, and 3 and from Foster pit samples 1 through 9 was determined by chemical analyses; only samples having over 0.05 percent antimony are listed.

[2] Core sample from 107.2 to 108.2 feet.

Radioactivity

All drill-hole and surface samples were submitted to routine radiometric analyses. Results were negative except for some sections of diamond-drill holes 1, 2, and 3, which have an equivalent uranium content ranging from 0.001 to 0.01 percent. Analyses for these samples are presented in table 30. The radioactive mineral was not identified.

TABLE 30. - Radiometric analyses of samples

Location	From feet	To feet	Type	eU, percent
DDH-1	199.7	202.9	Core	0.001
DDH-1	202.9	205.6	do.	.010
DDH-2	97.0	98.2	do.	.001
DDH-2	107.2	108.2	do.	.001
DDH-2	107.2	112.5	Sludge	.010
DDH-3	104.4	106.0	Core	.001
DDH-3	117.9	118.2	do.	.001
DDH-3	118.2	119.2	do.	.010
DDH-3	138.1	141.0	do.	.010
DDH-3	113.8	116.3	Sludge	.010
DDH-3	116.3	118.2	do.	.001
DDH-3	118.2	124.3	do.	.010
DDH-3	127.3	132.6	do.	.001
DDH-3	132.6	134.2	do.	.010
DDH-3	141.0	144.0	do.	.010
DDH-3	146.5	151.3	do.	.010

Miscellaneous Sampling

Omilak Mine

The Omilak mine workings were not accessible for examination or sampling; however, specimens typical of the varied mineral assemblage in the deposit were obtained and analysed for comparison with the Foster deposit. Descriptions and analyses of the samples are in table 31.

TABLE 31. - Analyses of Omilak mine specimens[1]

Specimen data		Percent			Ounces per ton	
No.	Description	Pb	Fe	Sb	Au	Ag
[2]21	Typical specimens of high-grade ore from shaft dump	55.2	12.1	1.0	0.13	88.01
[2]22	Specimen from small fracture exposed in Prospect pit 750 feet southwest of shaft	.06	3.4	31.7	.05	.19
[3]23	Specimen of high-grade galena from shaft dump	71.0	([4])	.7	.27	35.80
[3]24	Specimen of stibnite from shaft dump	7.5	([4])	32.3	.05	1.70

[1] Sample locations are shown on figure 4.

[2] Chemical analyses for copper, tin, and zinc:

Specimen	Percent		
No.	Cu	Sn	Zn
21	0.15	0.2	0.1
22	<.05	<.05	<.05

[3] Spectrographic analyses of specimens 23 and 24:

	Al	Sb	As	Bi	Sn	Ca	Cu	Pb	Mg	Ag	Fe	Mn	Ni	Si	Ti	Li
Specimen No. 23	E	C-	D-	F	D	A	G	A	G	D	C	D		E		E
Specimen No. 24	D	A	D-		D	A	E	A	C	D	B	D	F	F	F	C

Legend:
- A - more than 10 percent.
- B - 5 to 10 percent.
- C - 1 to 5 percent.
- D - 0.1 to 1 percent.

Legend (Con.):
- E - 0.01 to 0.1 percent.
- F - 0.001 to 0.01 percent.
- G - less than 0.001 percent.

[4] No assay.

Other Prospects

Small fragments of oxidized lead minerals were found at widely scattered intervals for about 3,500 feet to the south and southeast of the Foster prospect. Usually the bedrock source was not apparent, but one small gossan outcrop occurs 3,000 feet S. 60° E. of the Foster prospect (sample 17). The random distribution of these minerals along the crest and flanks of the same anticlinal structure suggests that they were derived from smaller deposits similar to the Foster prospect. Analyses of typical fragments are presented in table 32.

TABLE 32. - Analyses of miscellaneous samples[1]

No.	Description	Pb, percent
[2]17	Selected high-grade specimen from small gossan 3,000 feet S. 60° E. of Foster pit....................................	6.3
[2]18	Float specimen from crest of anticline 2,600 feet S. 22° E. of Foster pit...	([3])
[2]19	Float specimen from crest of anticline 3,500 feet S. 20° E. of Foster pit...	([3])
[2]20	Chip sample of greenstone dike 1,800 feet north of Foster pit. Dike is 15 to 20 feet wide at the east end and becomes narrower toward the west................................	([3])

[1] Sample locations are shown on figure 4.

[2] Petrographic analyses:

Sample 17: Limonite and cerussite with some galena.

Sample 18: Cerussite with some associated limonite.

Sample 19: Limonite with a relatively small amount of associated calcite. A trace of zinc is present but the zinc mineral was not identified.

Sample 20: An igneous rock that contains altered feldspar with some serpentine, pyroxene, amphibole, and small amounts of magnetite, pyrite, chlorite, calcite, biotite, and limonite.

[3] No assay.

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